BCC Annual Science Forum

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

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Motivation - Focus of interests

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→ 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

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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

Data

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- → 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°

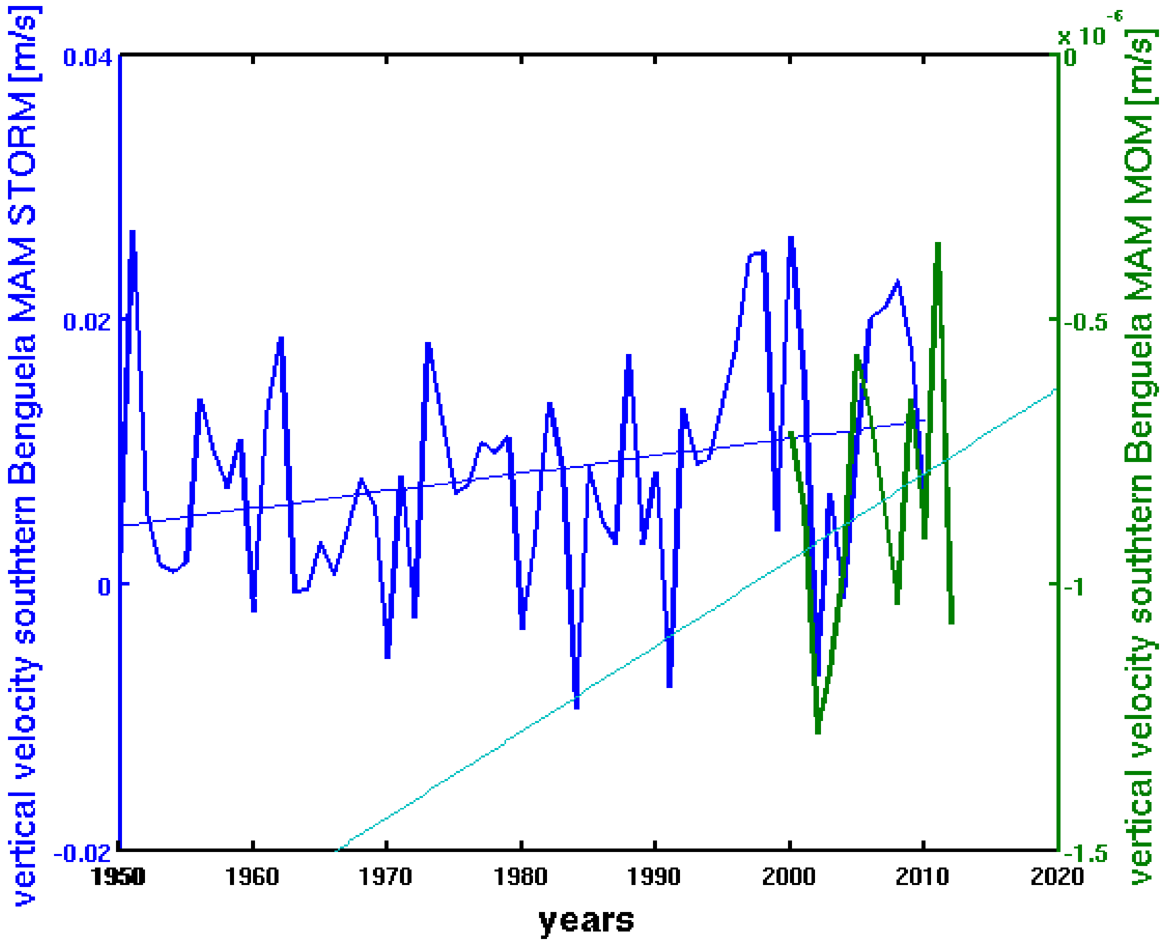
Long-term trends of Namibian upwelling

→ 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

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- → 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 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

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→ 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

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→ test Bakuns hypothesis

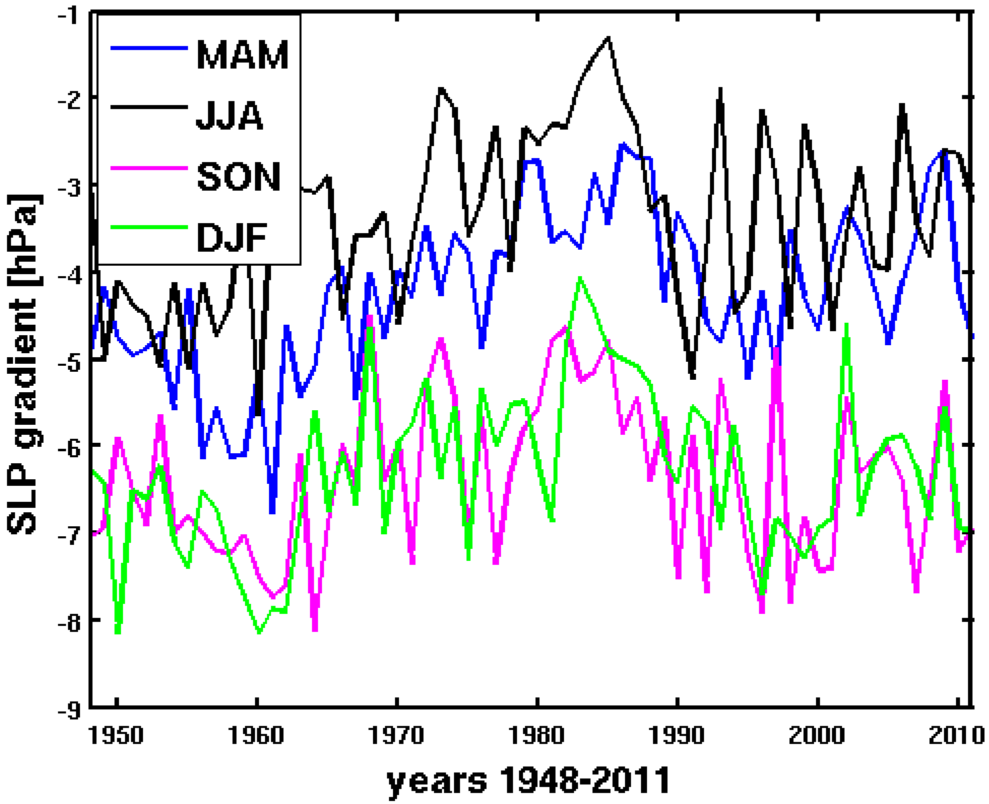
→ SLP differences between land and ocean

→ NCEP: significant positive trend in MAM and JJA

→ correlations with upwelling index of vertical velocities:

  → Northern Benguela: in MAM and DJF

  → Southern Benguela: MAM



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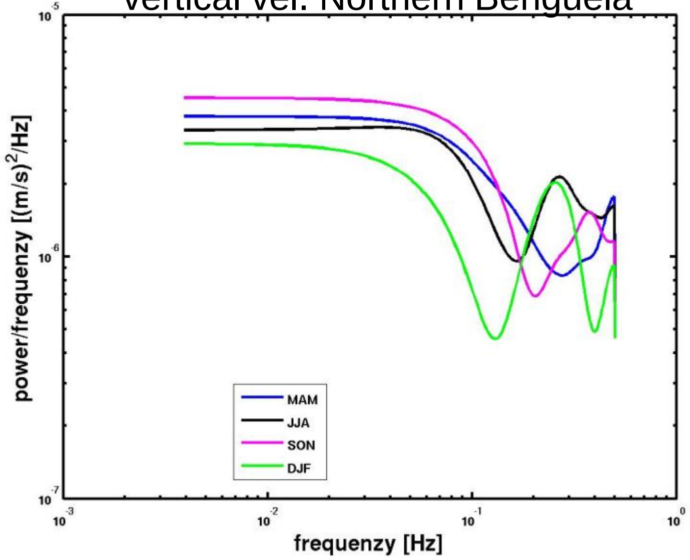
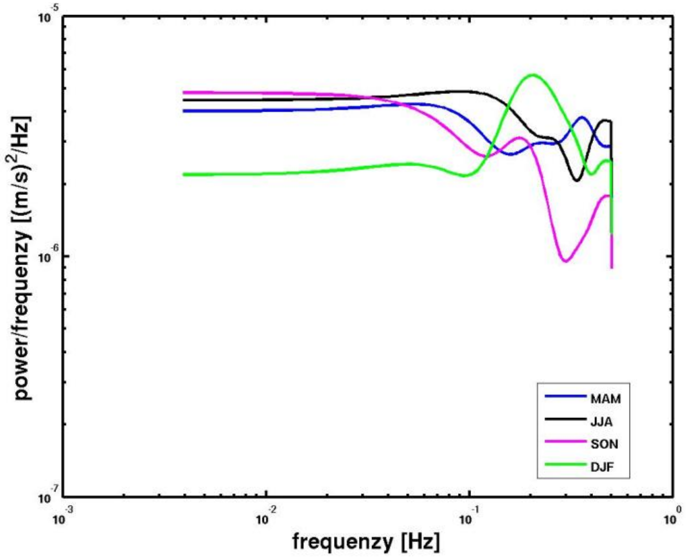
Decadal variabilities – spectral analysis

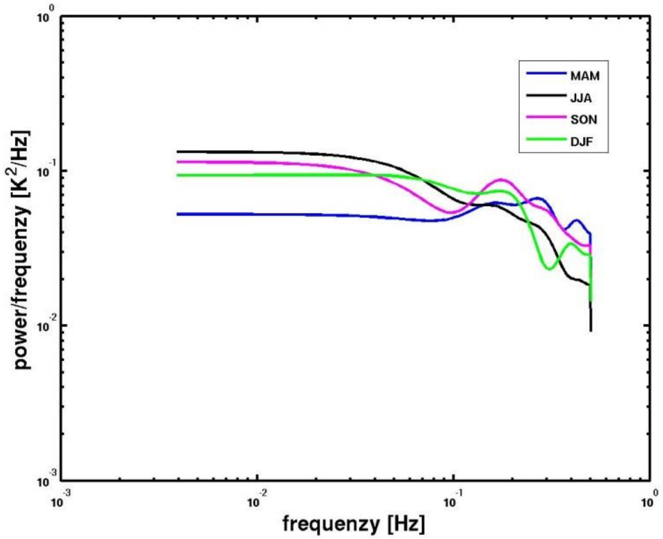
- → Northern Benguela:
  - → JJA, DJF 4 years; SON 2.5 years
- → Southern Benguela:
  - → DJF: peaks strongly at 5 years; SON weaker; MAM: 2.5 years
- → STORM:
  - → SON, DJF: 5 years; MAM: 3.5 years
- → HadlSST1:
  - → DJF, SON: 5 years; JJA: 12.5 and 10 years; MAM: 12.5 and 5 years

vertical vel. Northern Benguela

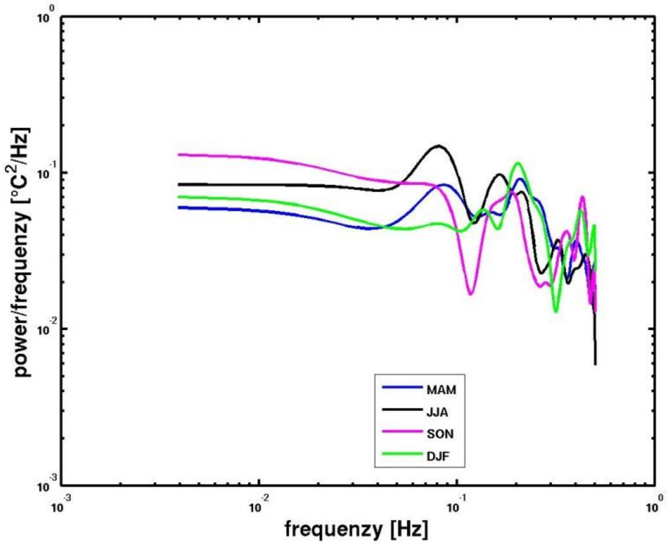


vertical vel. Southern Benguela





SST STORM



SST HadlSST1

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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