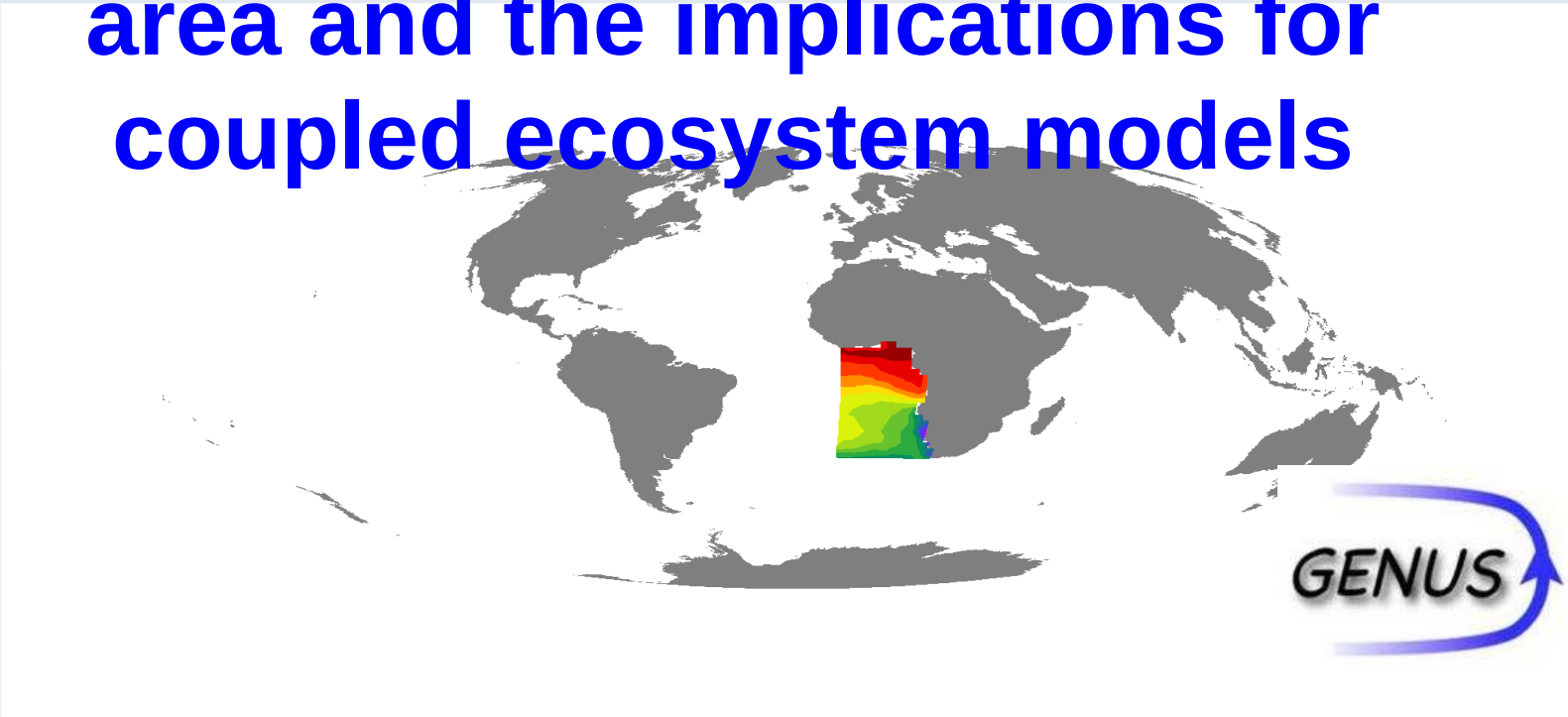
Temperature bias in a circulation model for the Benguela upwelling area and the implications for coupled ecosystem models



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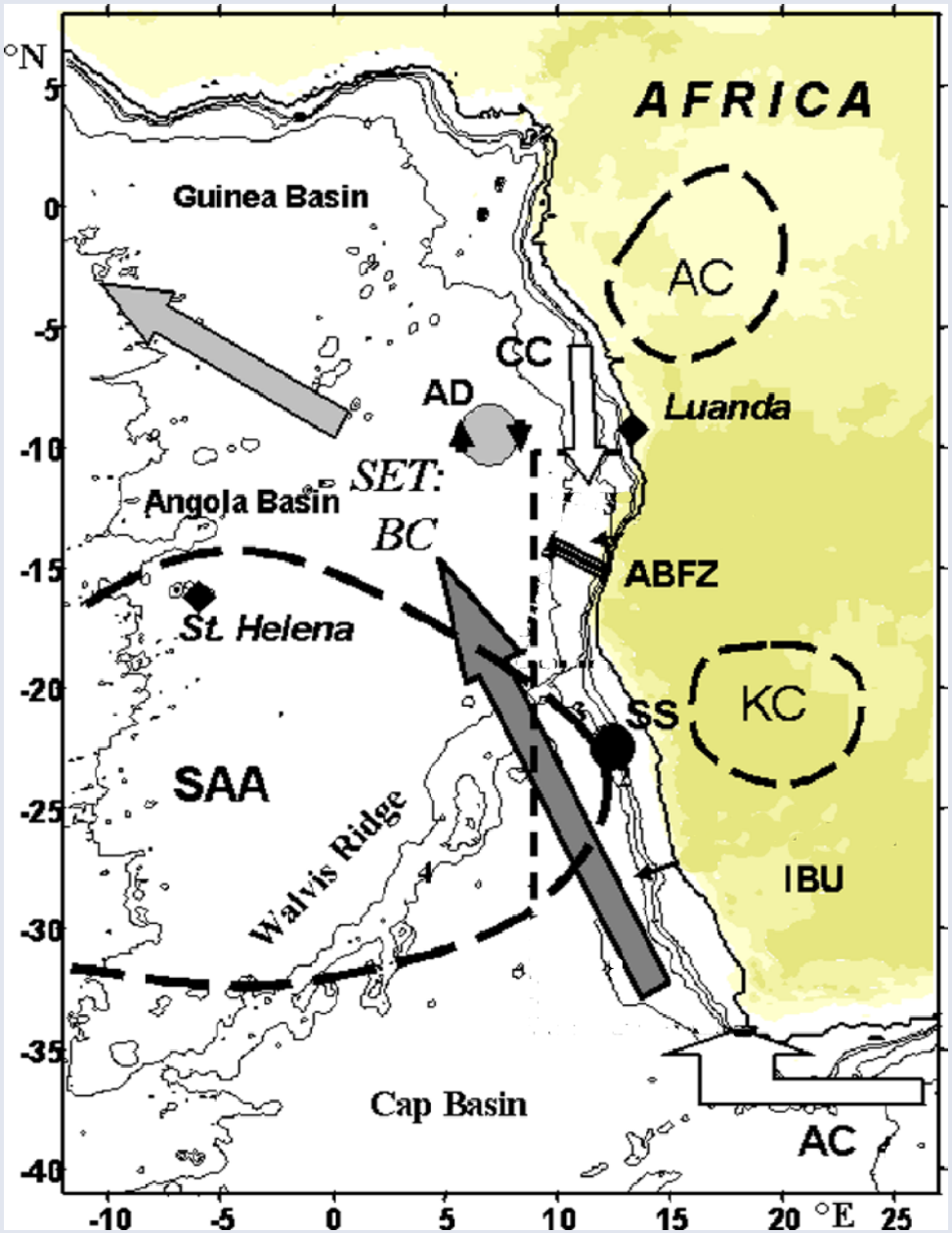
Contributions from: Tim Junker, Volker Mohrholz, Annethea Muller, Norbert Wasmund, Anja Hansen, Thomas Ohde ….

AIM

Synthesis of the knowledge on the Benguela upwelling System with a 3d coupled biogeochemical model (nitrogen cycle model):

- atmospheric drivers
- hydrographic fields, currents and transports, budgets
  → Eggert (Friday)
- upwelling
- primary producers
- zooplankton
- microbial mineralisation (water column + sediment)

The circulation model



Circulation model → MOM

Atmospheric drivers →

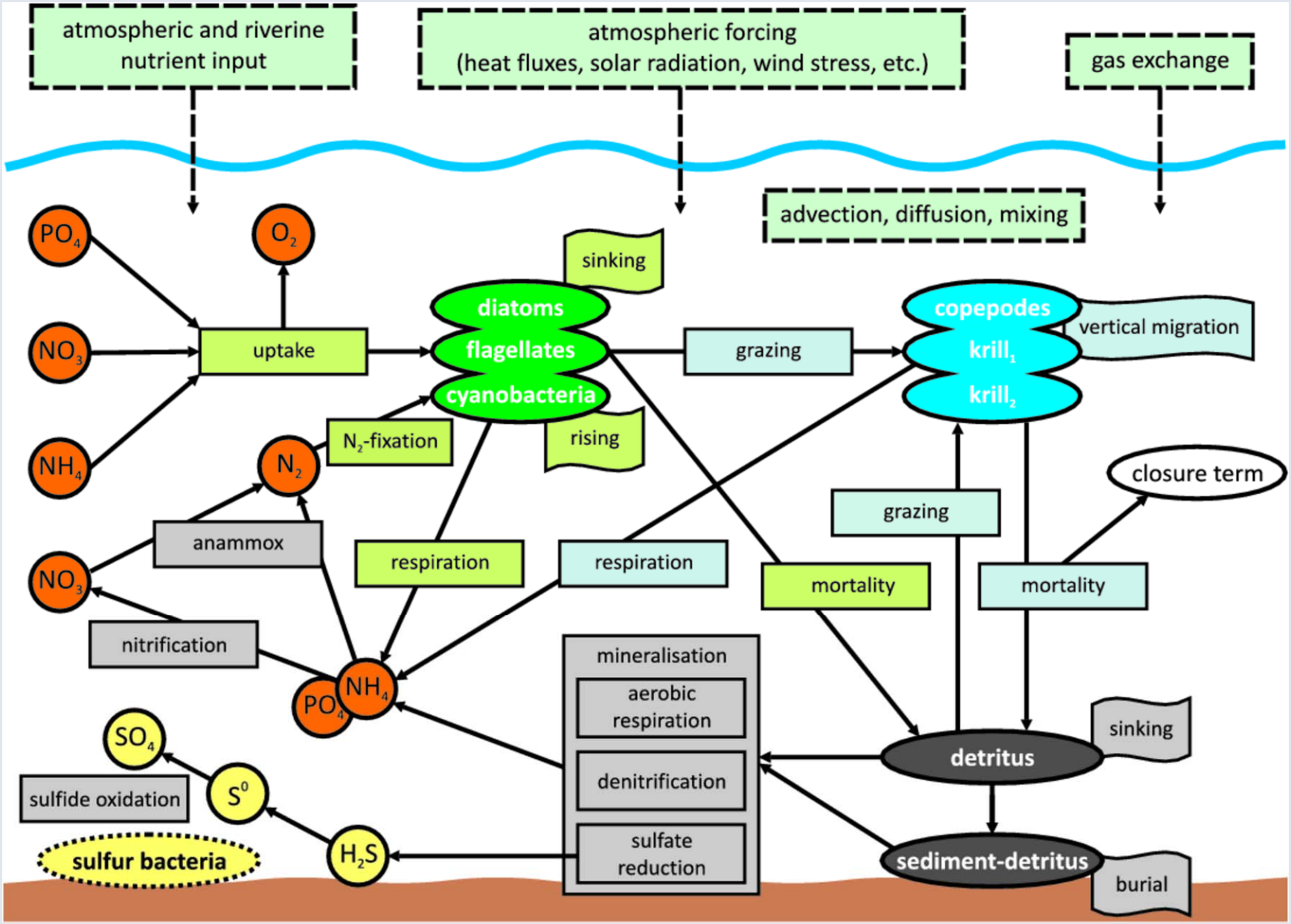
QuikSCAT/ASCAT

NCEP

Open boundaries → ECCO

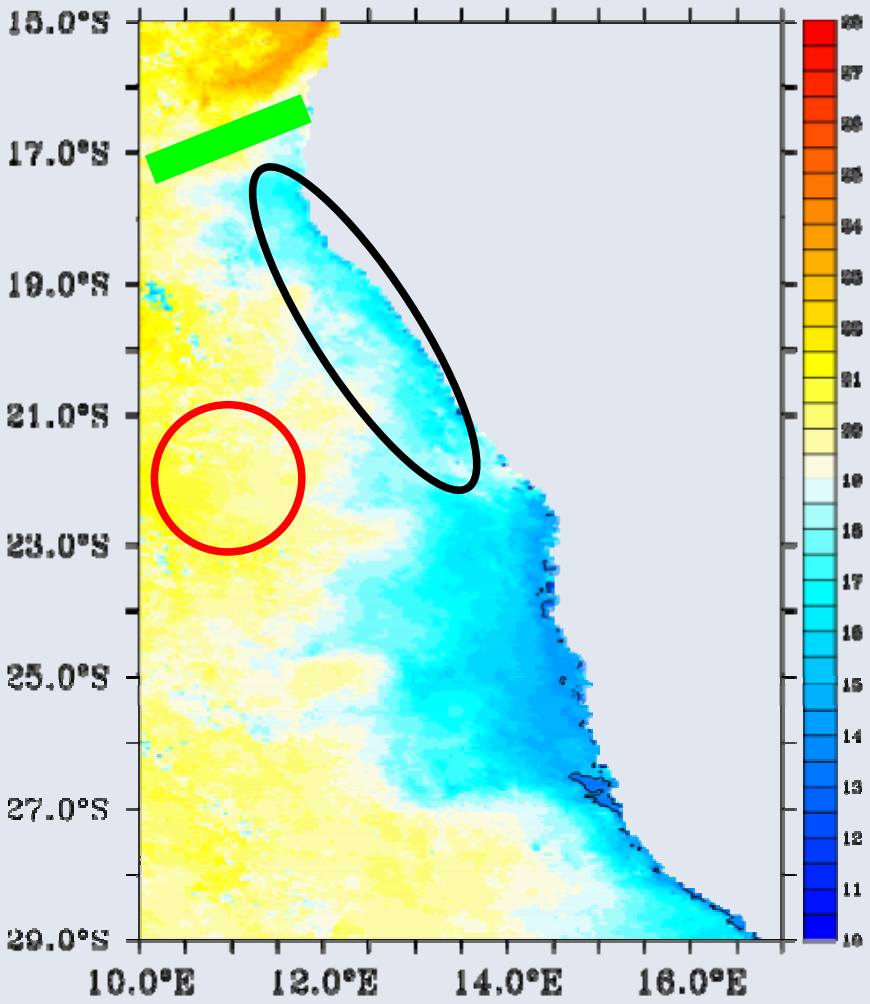
Atmospere circulation (Hagen et al. 2005)
SAA : South Atlantic Anticyclon
KC : Kalahari Cyclon
AC : Angola Cyclon

The ecosystem model

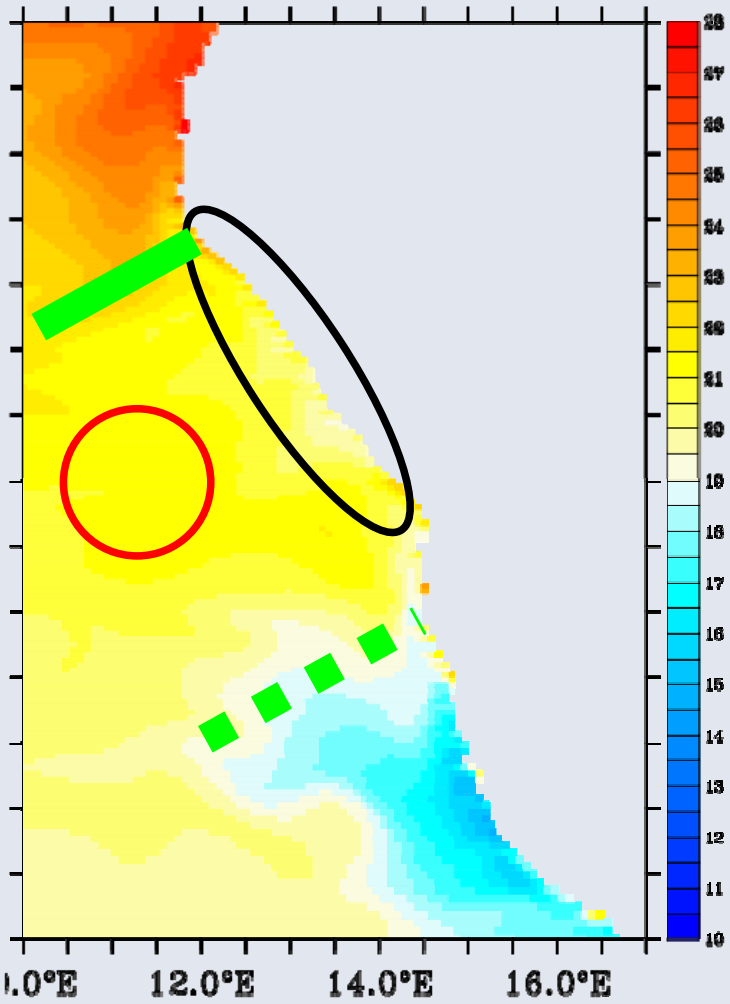


Ecosystem model → ERGOM (modified for specifics of the South-Eastern Atlantic)

The SST-bias



MODIS - SST



Model - SST with inappropriate surface forcing

Over-estimated SST - what is the reason?

Heat fluxes – one way coupling

Prescribe state variables, calculate fluxes.

$$Q^{surf} \approx Q^{short} + Q^{lat} + (4\sigma T_a^3 + C^{sens})(T_a - T_s).$$

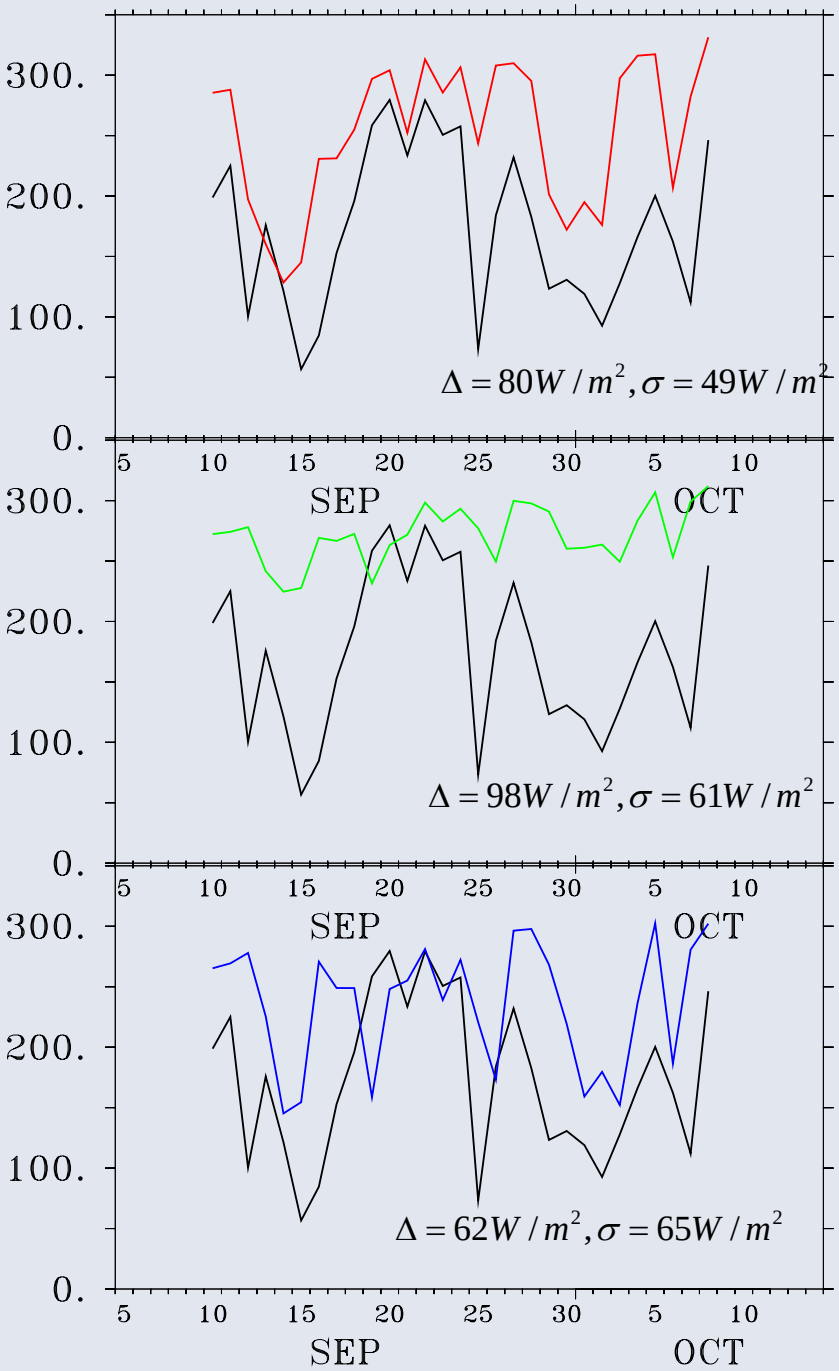
Keeps the ocean model close to T_a.

A steady state solution allways exists.

Steady state

$$T_s \approx T_a + \frac{Q^{short} + Q^{lat} + Q^{bot}}{4\sigma T_a^3 C_{corr} + C^{sens}}.$$

Downward shortwave radiation



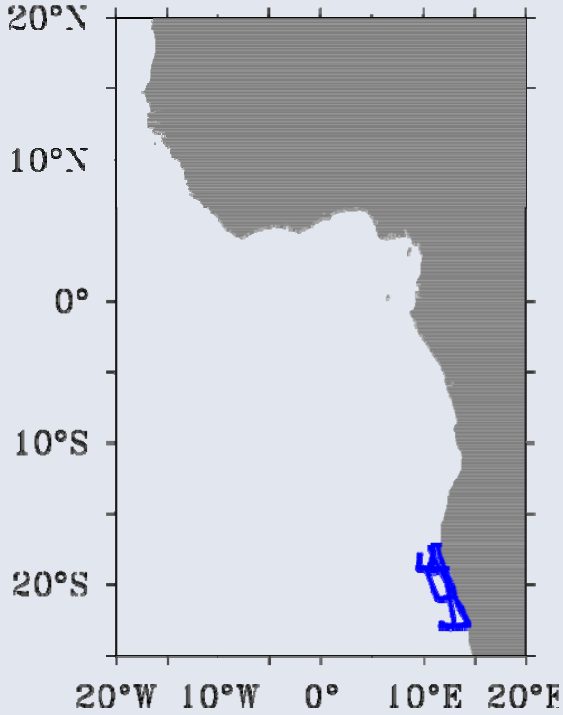
Pyranometer DISCOVERY 356 (2010) (black curve)

Several products at ships position and time

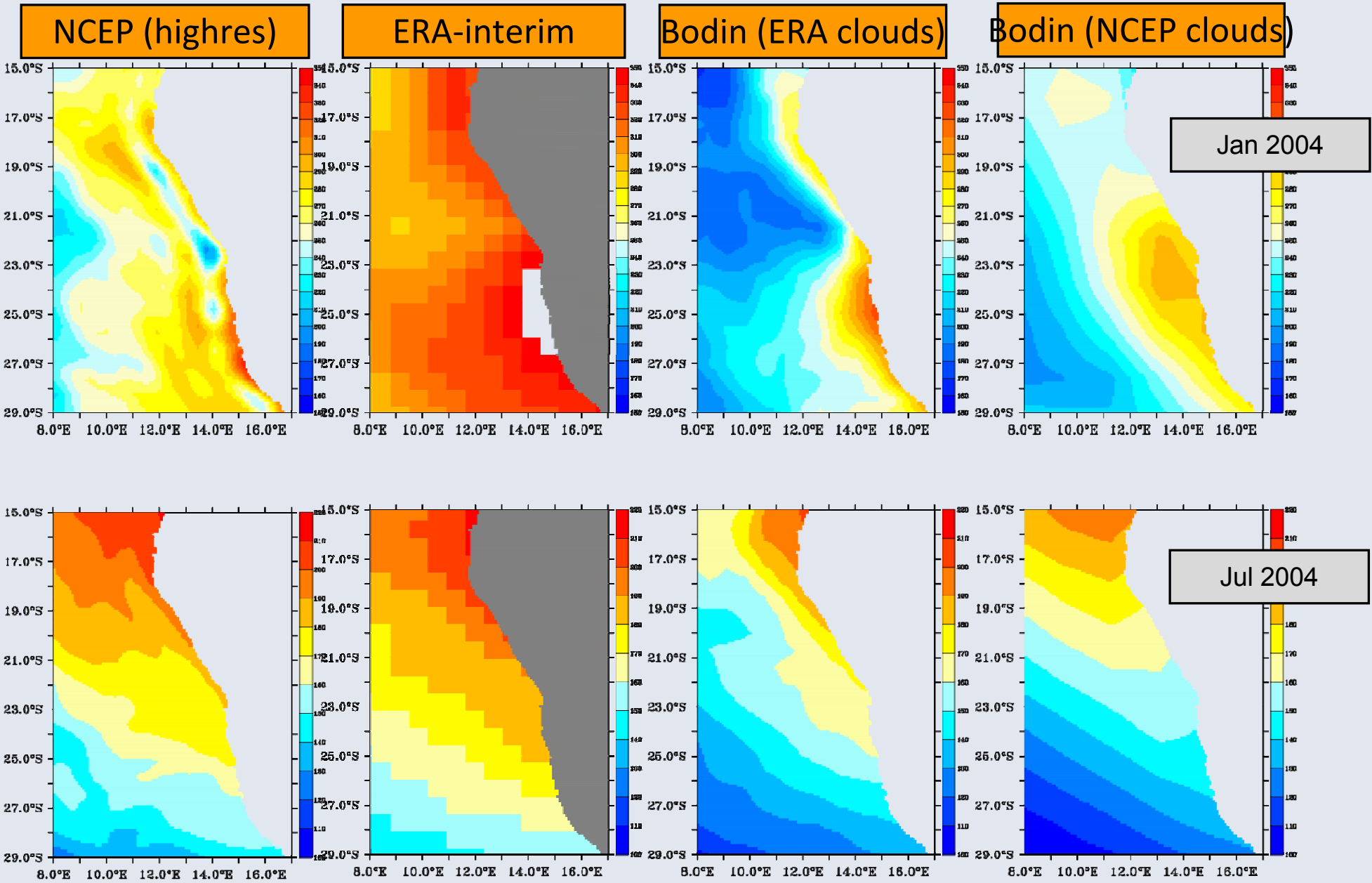
NCEP (highres)

ERA-interim

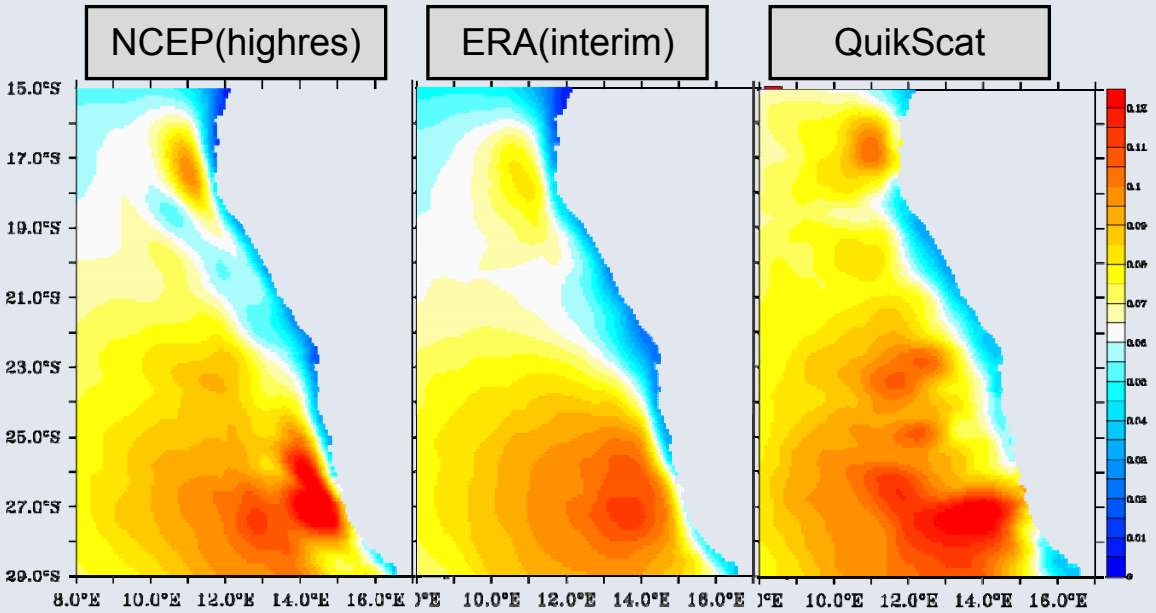
Bodin (ERA clouds)



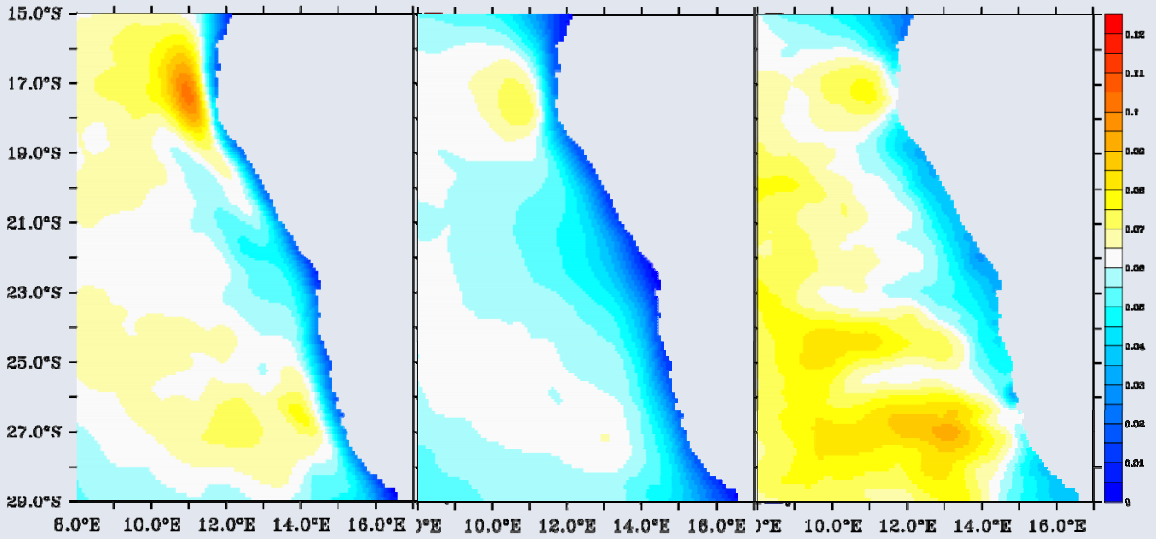
Downward radiation pattern



Typical wind stress pattern

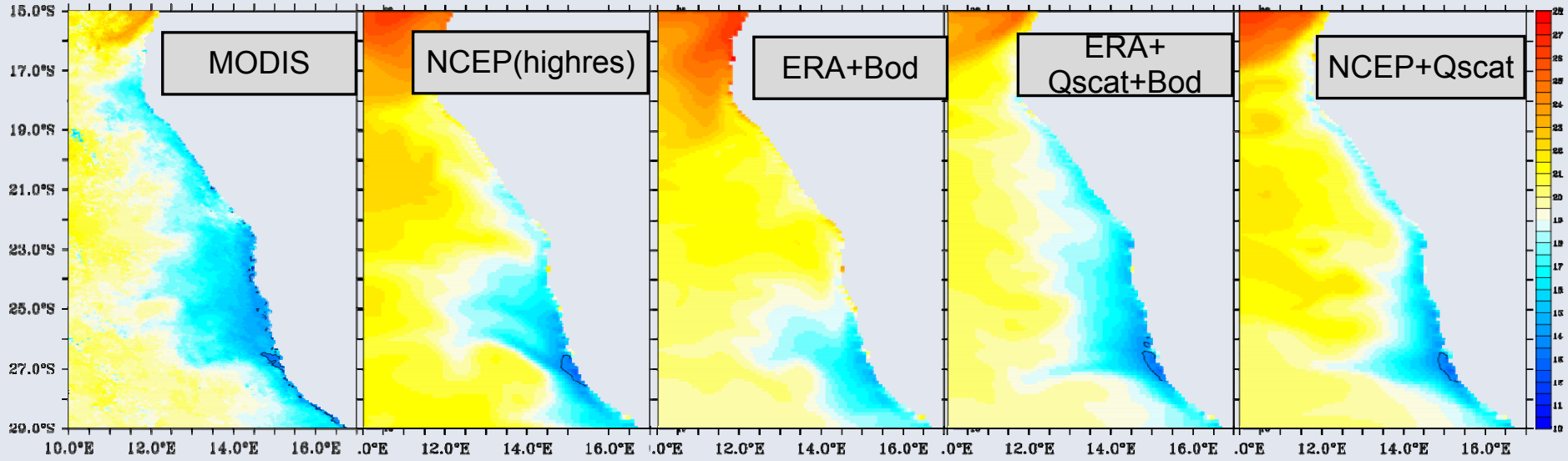


Jan 2004

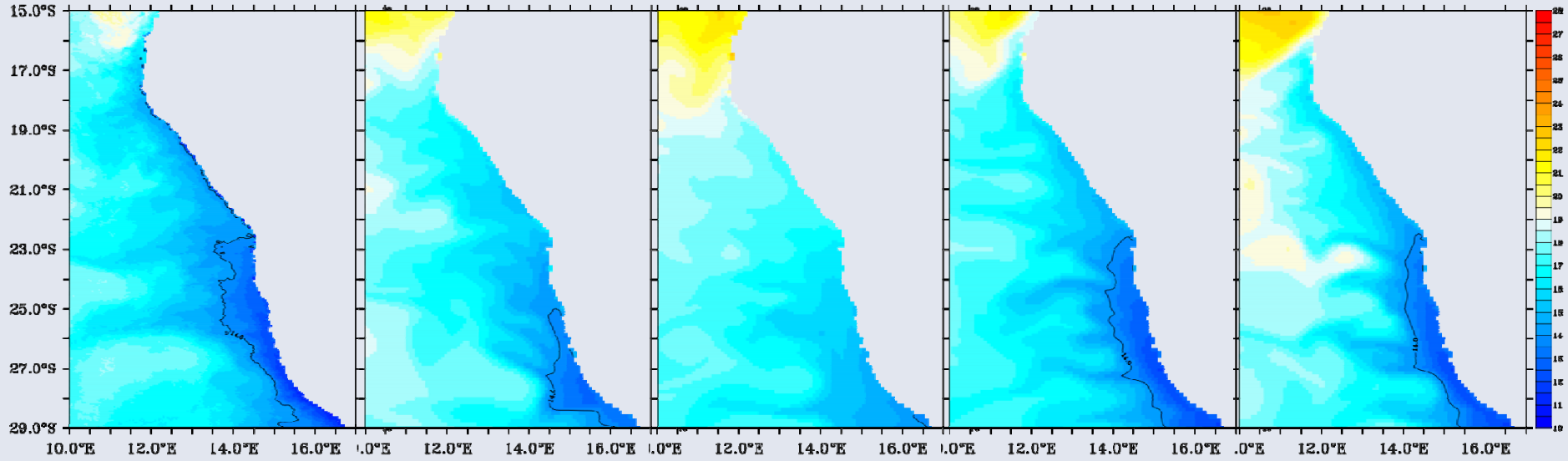


Jul 2004

Results - SST

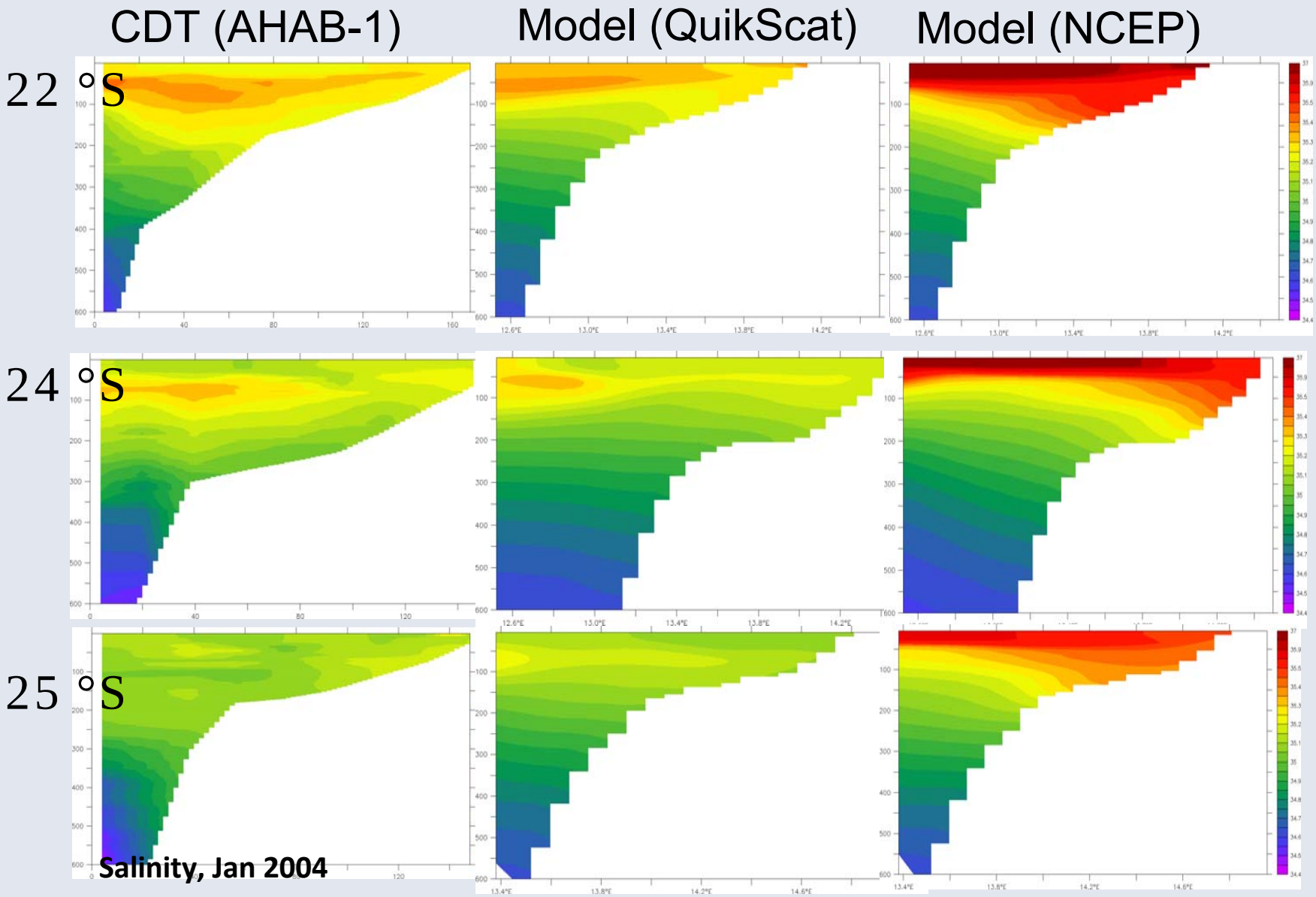


Jan 2004



Jul 2004

Results - salinity



Over-estimated SST - consequences for the ecosystem?

Temperature dependent processes

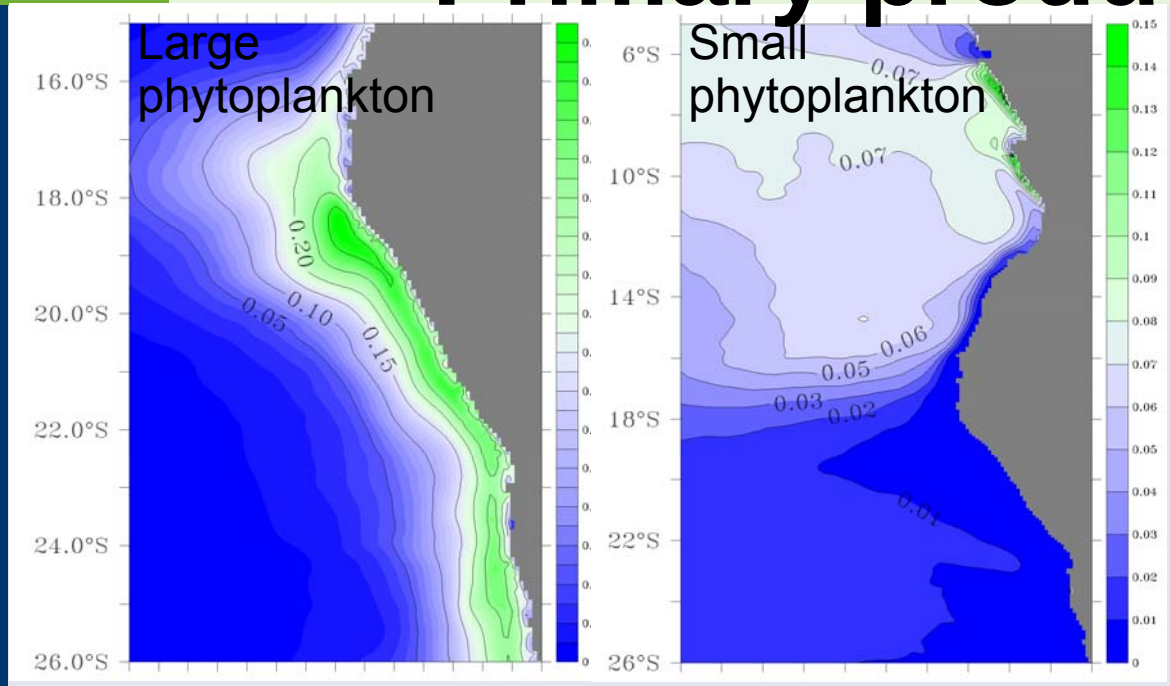
Surface gas fluxes

Phytoplankton
- growth rates
- respiration rates
- minimum temperature for fixation

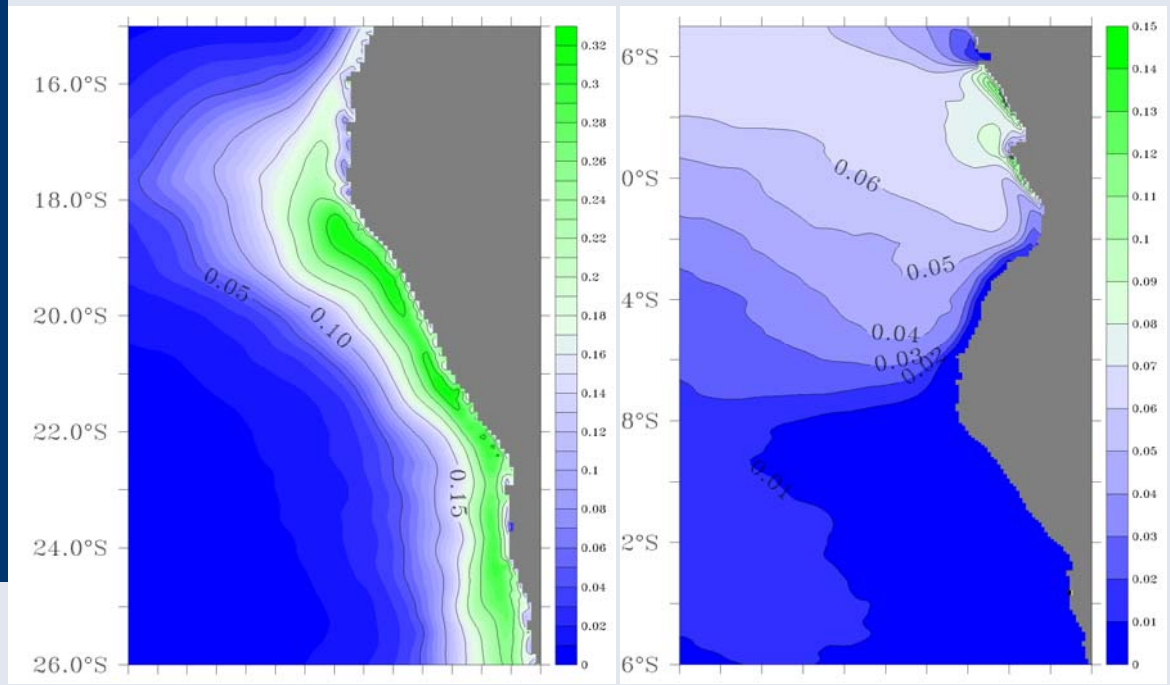
Zooplankton
- growth rates
- respiration Rates
- grazing activity
- optimum/ maximum temperatures
- migration rules
- oxygen rules

Microbes
Q_{10} rules for
- nitrification
- denitrification
- ANAMMOX
- sulphate reduction
- autolithotrophs
- DNrA

Primary producers

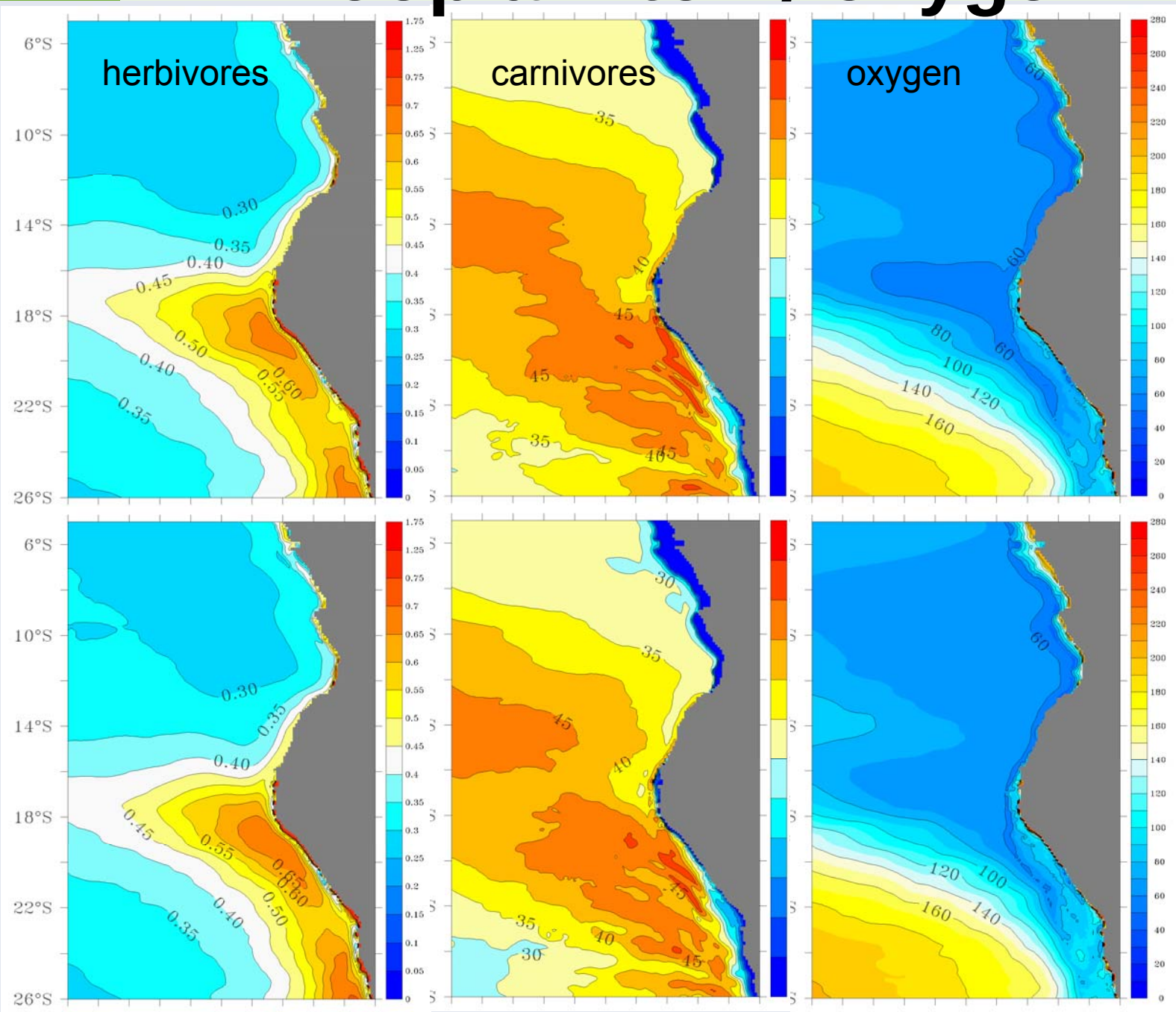


large positive SST-bias



reduced SST-bias

Zooplankton / oxygen



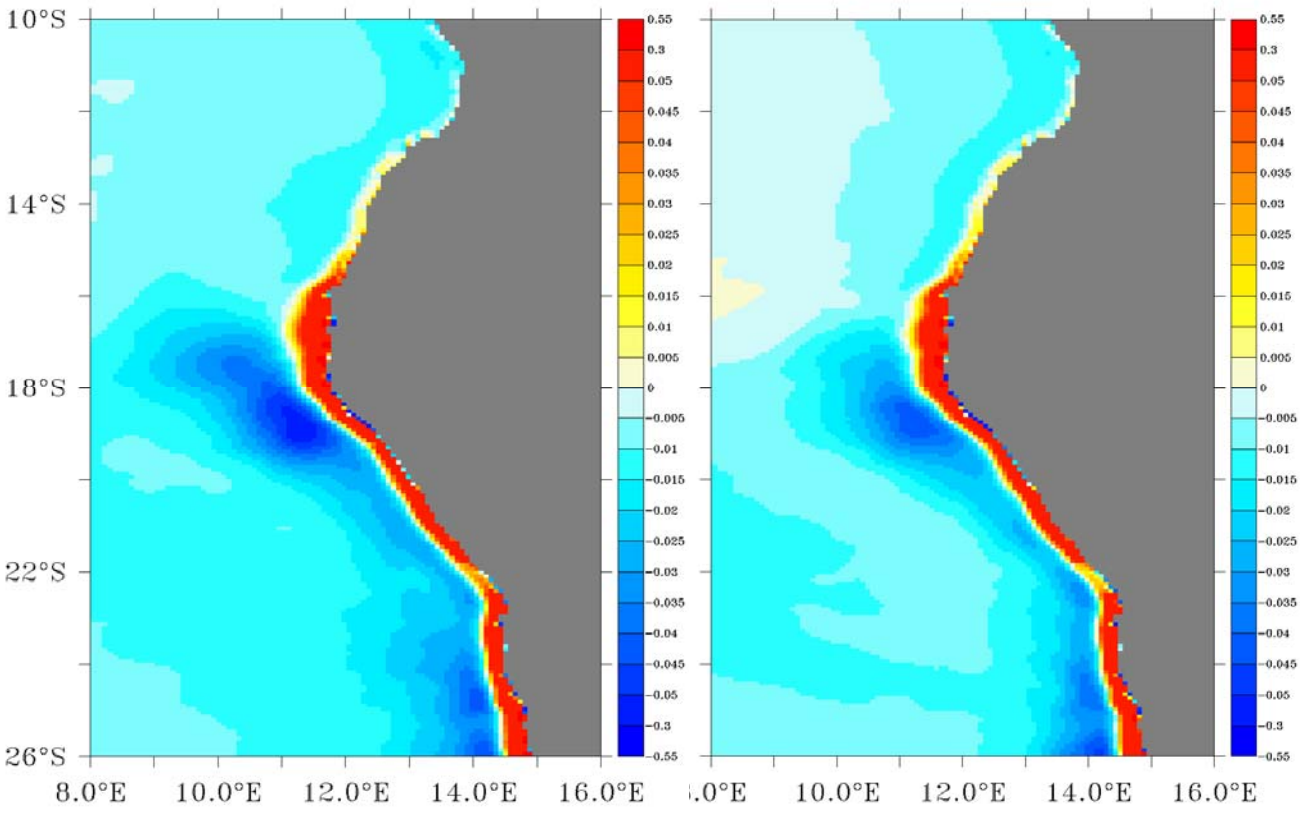
large positive SST-bias

reduced SST-bias

Oxygen surface flux

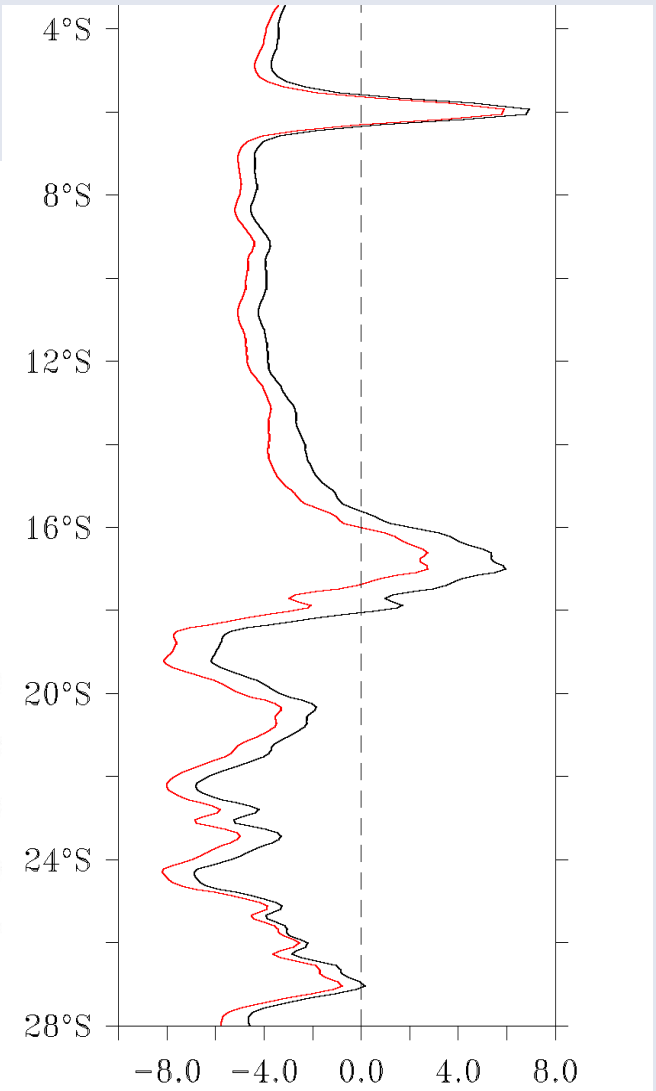
large positive SST-bias

reduced SST-bias



mol m^{-2} d^{-1}

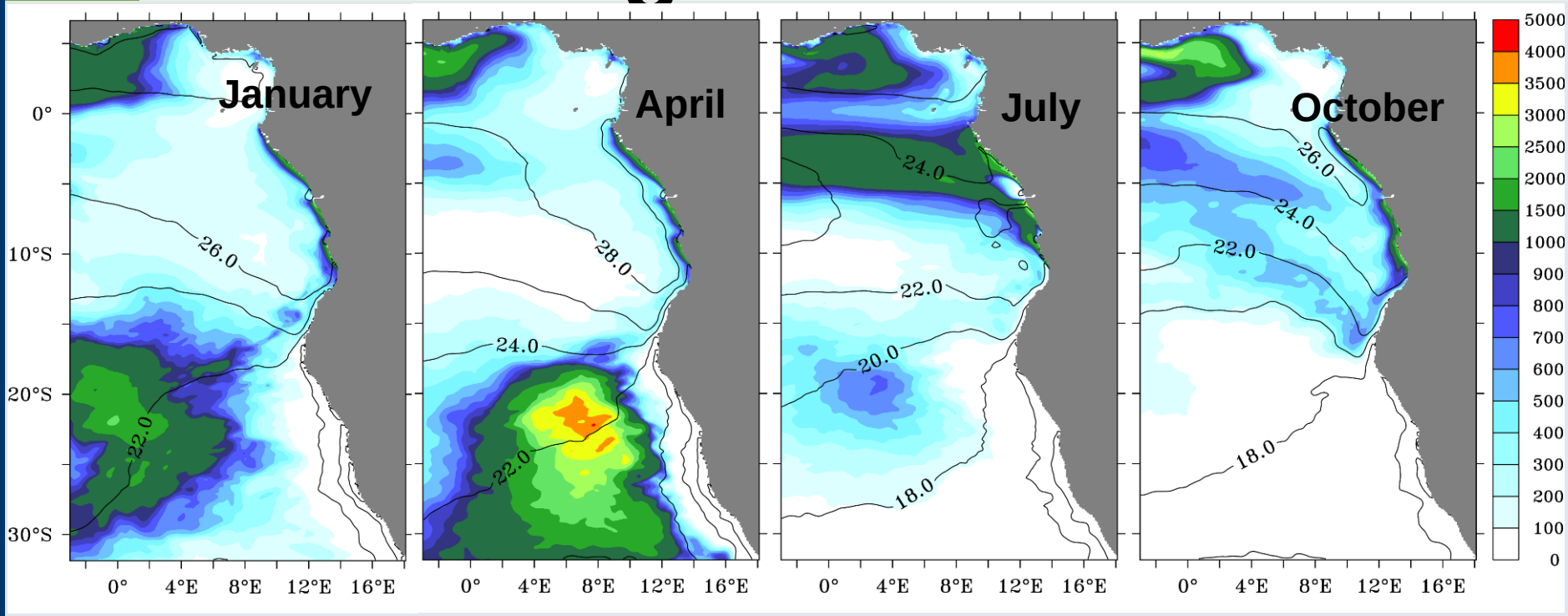
mol m^{-2} d^{-1}



kmol m^{-2} d^{-1}

positive → into the ocean

Nitrogen fixation?



Fixation [µmol m^{-2} d^{-1}]

ERGOM:

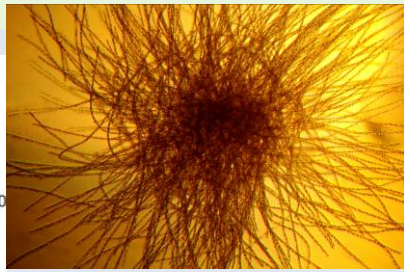
- Low assimilation rates
- No Liebig limitation by DIN, but by DIP
- Inhibited growth in colder water (T < 20°C)

→ growth if

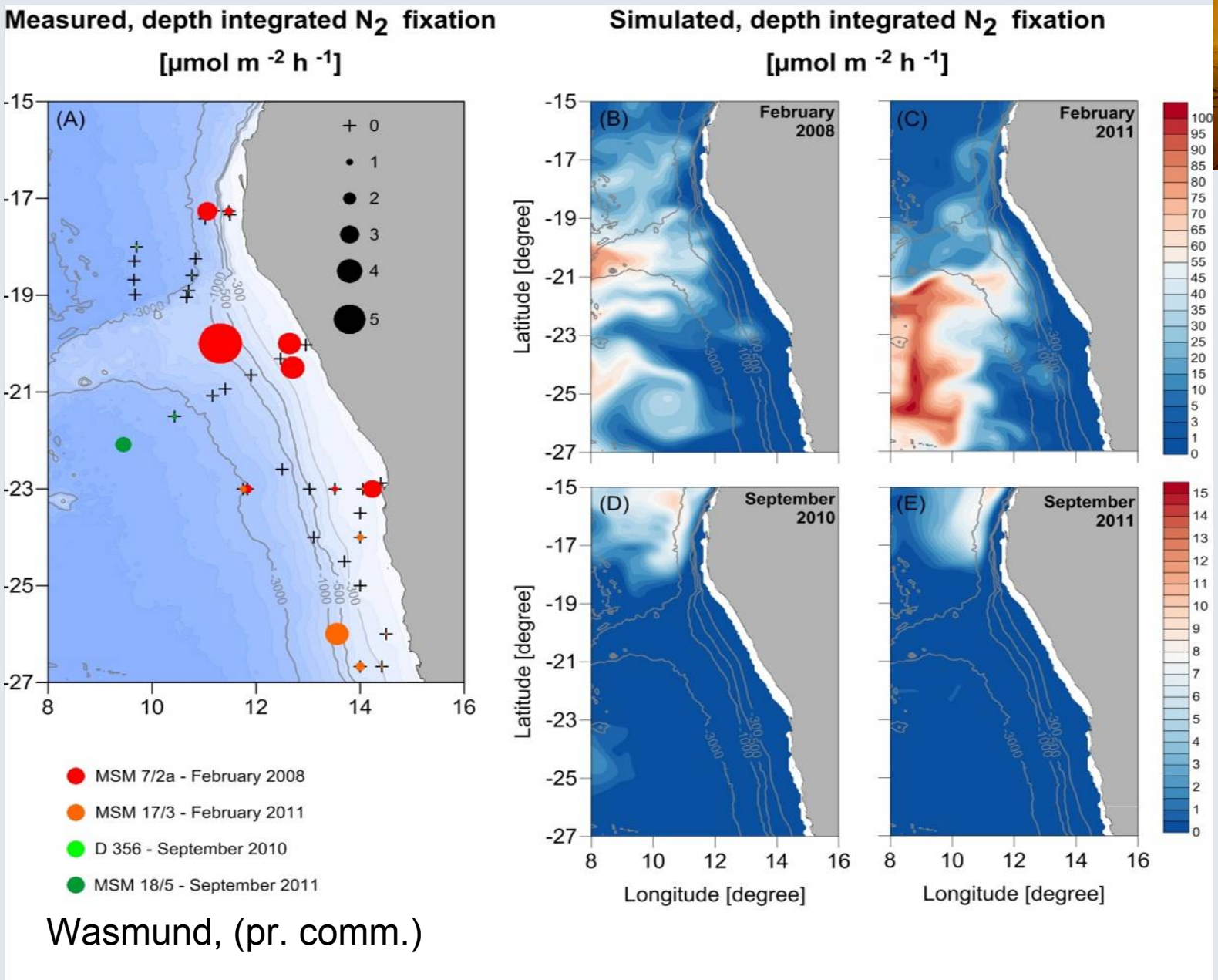
- No competition with phytoplankton, DIN exhausted
- DIP is available
- warm waters

Be at the right place to the right time!

Nitrogen fixation?



T. Ohde



Wasmund, (pr. comm.)

Conclusion

- **Consistent**, dense **data set**: hydrography … zooplankton
  Analysis of fluxes within and through the system
  → Eggert (Friday)

- **Surface fluxes** determine the SST pattern

  Heat fluxes : large scale distribution
  Wind stress : coastal SST – gradients, upwelling strength

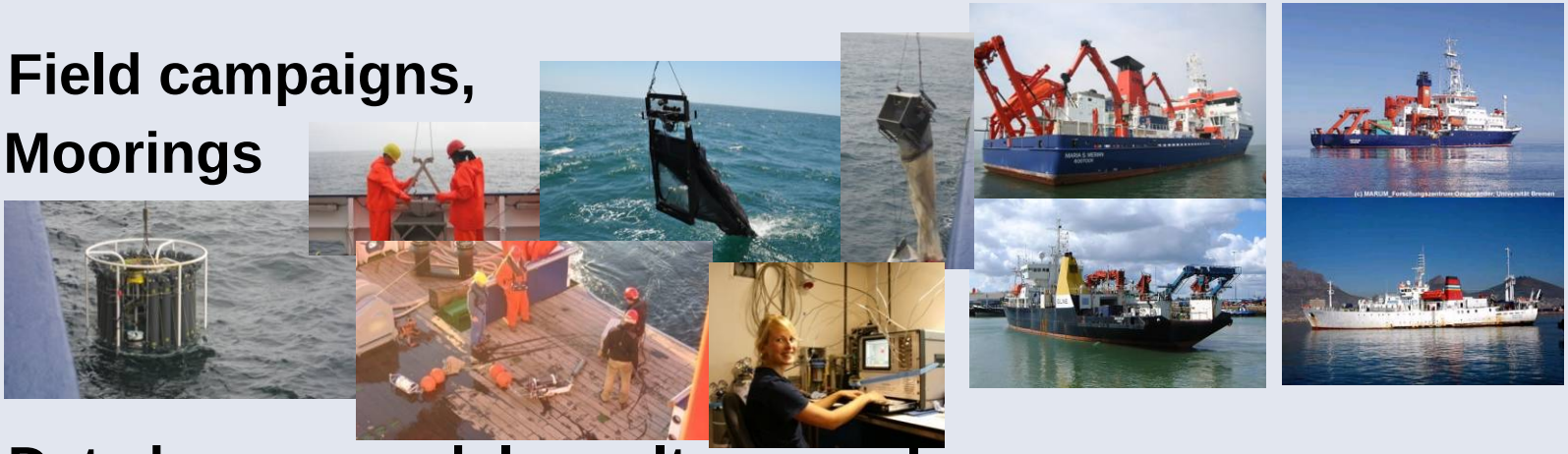
- **Standard flux products** may have a large bias.
  The coupling scheme stabilises the model.
  Radiation erors lead to a bias, no model drift.

- **Long term averages** of biogeochemical variables are **robust** against a SST bias.

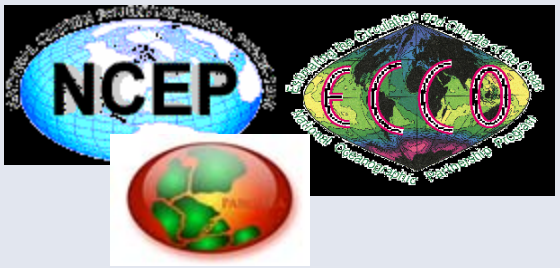
- Model results support the hypothesis of **nitrogen fixation** within the subropical gyre.
  Denitrification in the BUS and sufficient **SST** limit the growth of diazotrophs.

Thanks to the GENUS Community!

- **Field campaigns, Moorings**



- **Data bases, model results, reanalyses**



- **Satellite data**

- **Numerical Modelling**
  MOM

HLRN

GENUS