Tropical Atlantic Biases in current Coupled General Circulation Models:
Tropical Atlantic Biases Workshop
23-25 March 2011, Miami
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Model biases in the tropical Atlantic

• Current coupled climate models show very poor performance in simulating tropical Atlantic climate
• Biases in mean state and variability
• Similar biases are present in both seasonal hindcasts and climate simulations (still there in CMIP5)
• Intercomparison studies: Davey et al. (2002), Richter and Xie (2008), Joly and Voldoire (2009)
• Bias origin: local and remote processes
Mean State
CMIP 20C3M simulations: SST bias
ref.: icoads JJA

Richter and Xie (2008)
Precip bias - ref. CMAP JJA 1991-2001
ENSEMBLES seasonal hindcasts

Caminade et al. (2009)
Zonal wind (850 hPa) bias - ref. NCEP JJA 1991-2001
ENSEMBLES seasonal hindcasts

Caminade et al. (2009)
Seasonal Evolution
What is the seasonal evolution of the biases?

Longitude-time sections of equatorial SST bias and surface winds

Richter and Xie (2008)
MAM sfc zonal wind vs. JJA SST at the equator

Richter and Xie (2008)
Drift time scale and Variability
Drift already present after 1 month

Start May
Month 1

Start February
Month 5-7

Surface Temperature [°C]
Bias: EXP(CenOfmkE2001S001M010) regarding ERA-40 reanalysis
Forecast start month and years: February / 1970-2005
FC period: months 5-7 (JJA), ens-members: 9

Doblas-Reyes (2009)
Turbulent heat flux feedback

Q(t) = q(t) – αT(t)
α = - Cov_{TQ}(τ)/Cov_{TT}(τ)

T: lags of 1, 2 & 3 months
If α > 0, negative feedback

Frankignoul et al. (2004)
Bias origin: local and remote processes
Southeast Atlantic: low clouds and coastal upwelling

Large and Danabasoglu, 2006
Coastal upwelling: the spatial scale question?

High-Res ocean simulation (5km) (Capet 2008)
Spatial structure of coastal winds?

QuikSCAT

JJA wind stress (Neg. -> South)
Capet et al. 2008
UCLA Mesoscale Coupled Model (UMCM)

SST (°C)
Mean bias -0.63 K

Mean JJA 2002

Wind (m.s⁻¹)
Mean « bias »: -0.88 m/s (~11%)

Boé et al. 2011
Summary

- Large SST biases (along the coast and equator): permanent Atlantic and Benguela Nino’s
- Common error patterns in surface winds and precipitation already exist in uncoupled atmospheric GCMs with “perfect” SSTs. These biases are amplified in the coupled models (CMIP3 and seasonal forecasting)
- Seasonal aspects are important (spring season when the westerly bias in equatorial winds deepens the thermocline in the east)
- Atmospheric dynamics: surface wind biases are consistent with terrestrial precipitation biases
- Very fast drift (a few months)
- Large diversity of causes: local and remote effects (both zonal and meridional), spatial scales (SST-wind coupling), diurnal cycle, boundary and mixed layer physics, ...