What Drives Equatorial Boundary Layer Winds ?

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Clim Dyn (2008) 31:587–598
DOI 10.1007/s00382-008-0364-z

On the origin of equatorial Atlantic biases in coupled general circulation models

Ingo Richter · Shang-Ping Xie

“Along the equator, models fail to develop the eastern cold tongue, with SST gradients opposite to observations […].”

Clim Dyn (2014) 43:2963–2984
DOI 10.1007/s00382-013-2036-x

Are atmospheric biases responsible for the tropical Atlantic SST biases in the CNRM-CM5 coupled model?

A. Voldoire · M. Claudon · G. Caniaux ·
H. Giordani · R. Roehrig

“Wind biases are thus likely a local and/or remote response to deficiencies in the atmospheric model physics.”

Climate Dynamics (2019) 52:5927–5946
https://doi.org/10.1007/s00382-018-4489-4

CrossMark

The role of sea surface temperature in the atmospheric seasonal cycle of the equatorial Atlantic

Lander R. Crespo[1] · Noel Keenlyside[1] · Shunya Koseki[1]

Received: 24 January 2018 / Accepted: 5 October 2018 / Published online: 10 October 2018

“[…], further investigation on the potential feedback of zonal winds on SST is needed to completely understand the role of the coupling between the ocean and the atmosphere […].”

ICON - ICOsahedral Nonhydrostatic

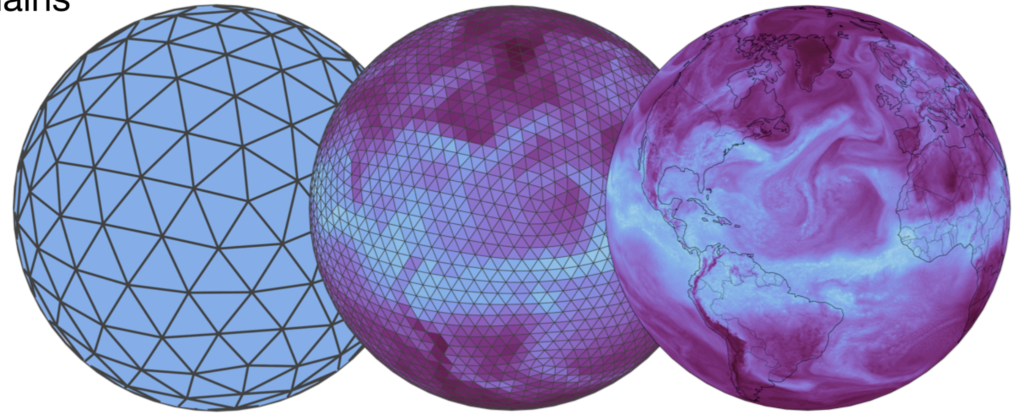
A. Non-hydrostatic model on global domains

B. Unstructured triangular grid

C. 5km resolution

D. 90 levels:
- top at 75km with 400 m
- bottom with 25m

E. 2-year simulation output: 01/2020 – 02/2022



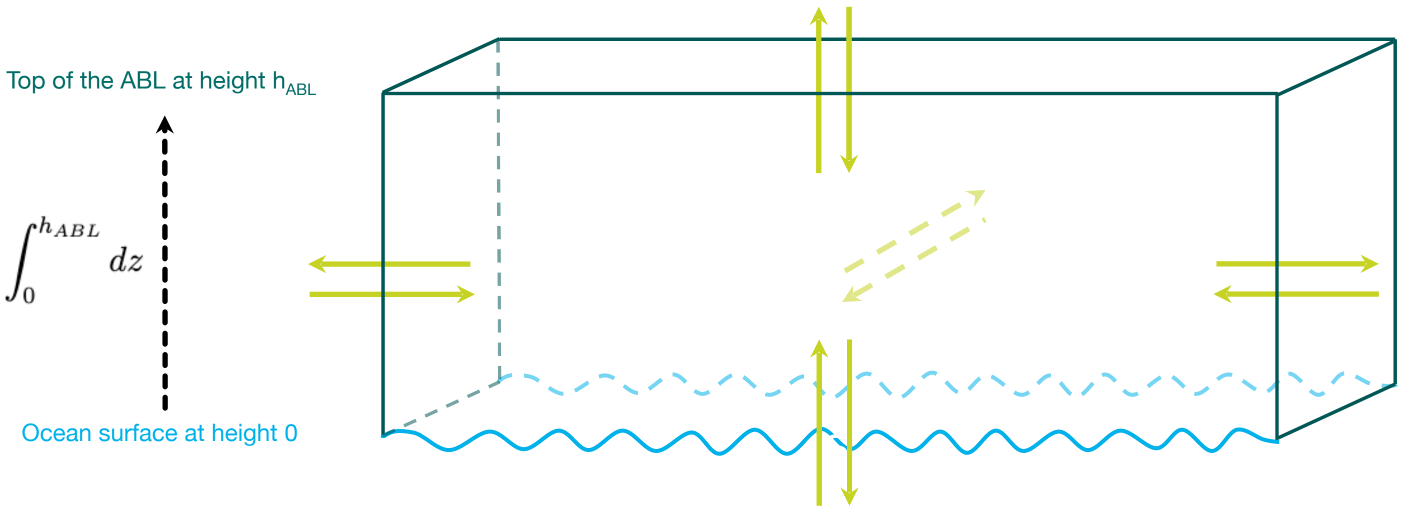
next GEMS

credit: Lukas Kluft, MPI-M

Momentum Budget Analysis

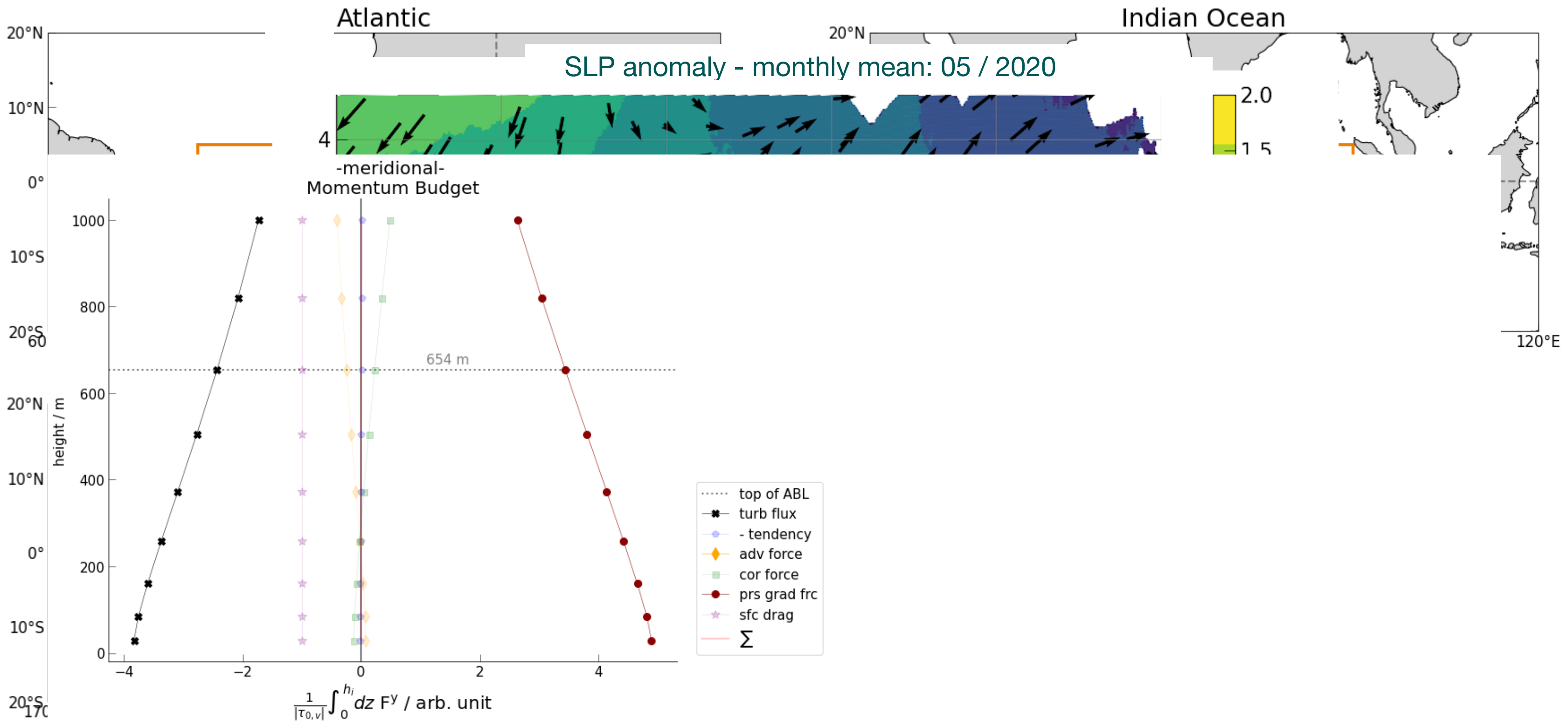
<u>Zonal:</u>

$$\underbrace{\frac{1}{|\tau_{0,u}|}\int_0^{h_{ABL}} dz\ \frac{\partial \bar{u}}{\partial t}}_{\text{tendency}} = \frac{1}{|\tau_{0,u}|}\left[\underbrace{-\int_0^{h_{ABL}} dz\ \bar{\mathbf{u}}\nabla\bar{u}}_{\text{advection force}} \underbrace{+\int_0^{h_{ABL}} dz\ f\bar{v}}_{\text{coriolis force}} \underbrace{-\frac{1}{\rho}\int_0^{h_{ABL}} dz\ \frac{\partial \bar{p}}{\partial x}}_{\text{pressure gradient force}} \underbrace{-\frac{1}{\rho}\tau_{h,u}}_{\text{turb flux}} \underbrace{+\frac{1}{\rho}\tau_{0,u}}_{\text{sfc drag}}\right]$$



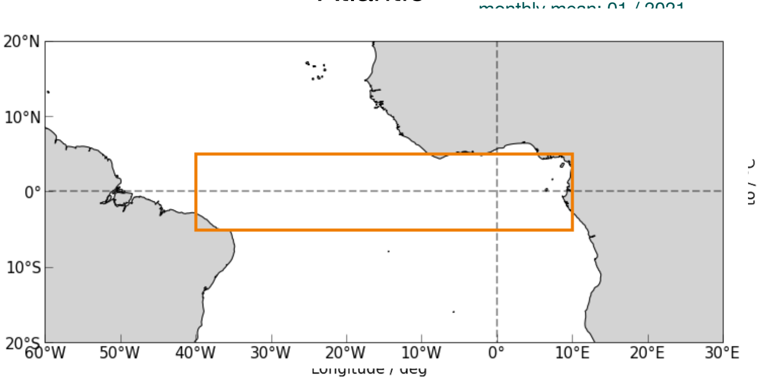
Equatorial Boundary Layer Wind ⚖️:

Equatorial Atlantic

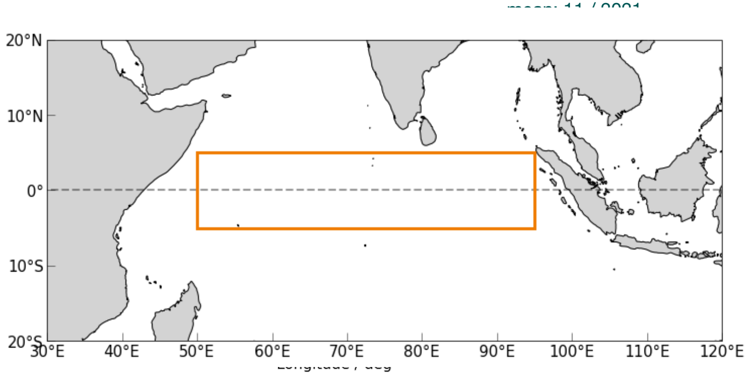


Type 1/2: Zonal Wind Belt

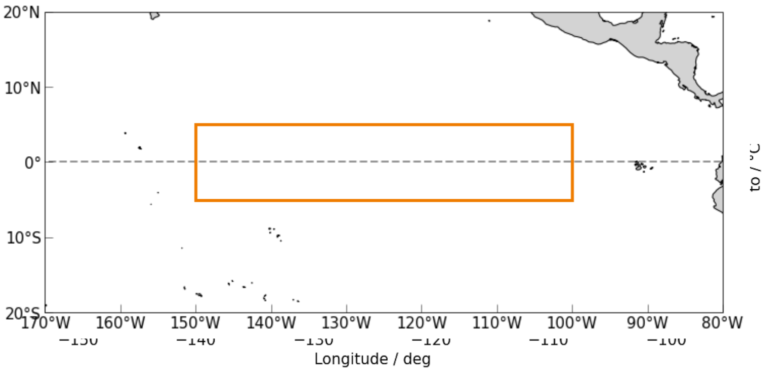
Atlantic



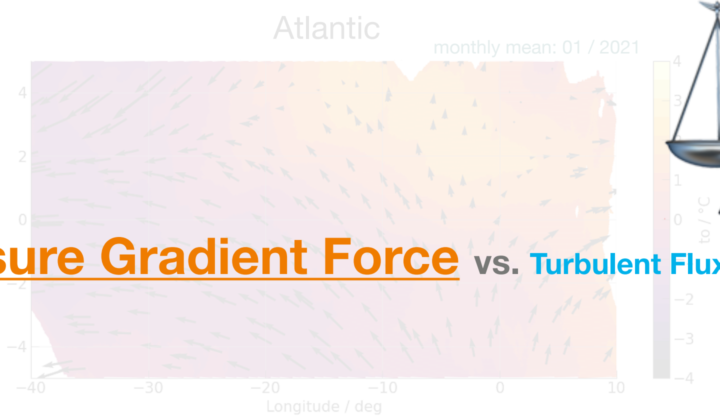
Indian Ocean

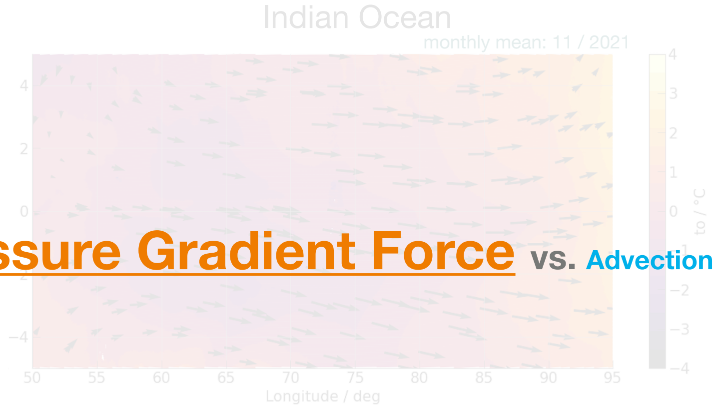


Eastern Pacific



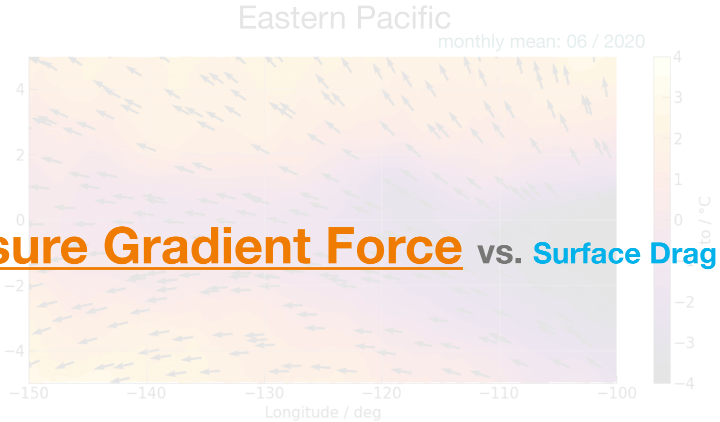
Type 1/2: Zonal Wind Belt





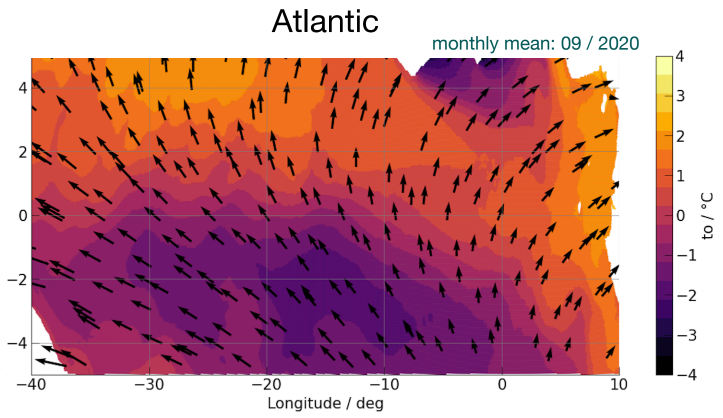
Pressure Gradient Force vs. Turbulent Flux

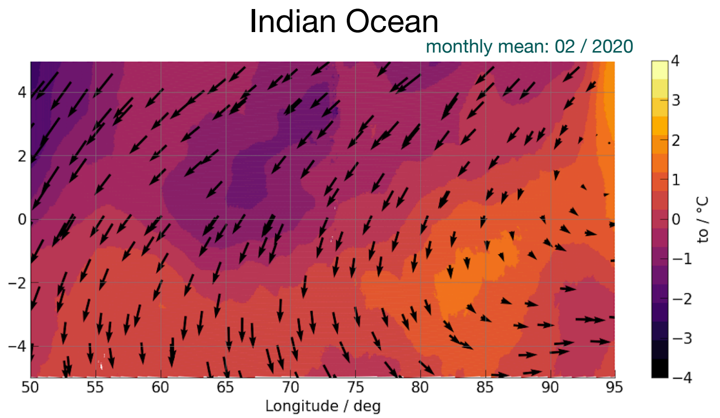
Pressure Gradient Force vs. Advection Force



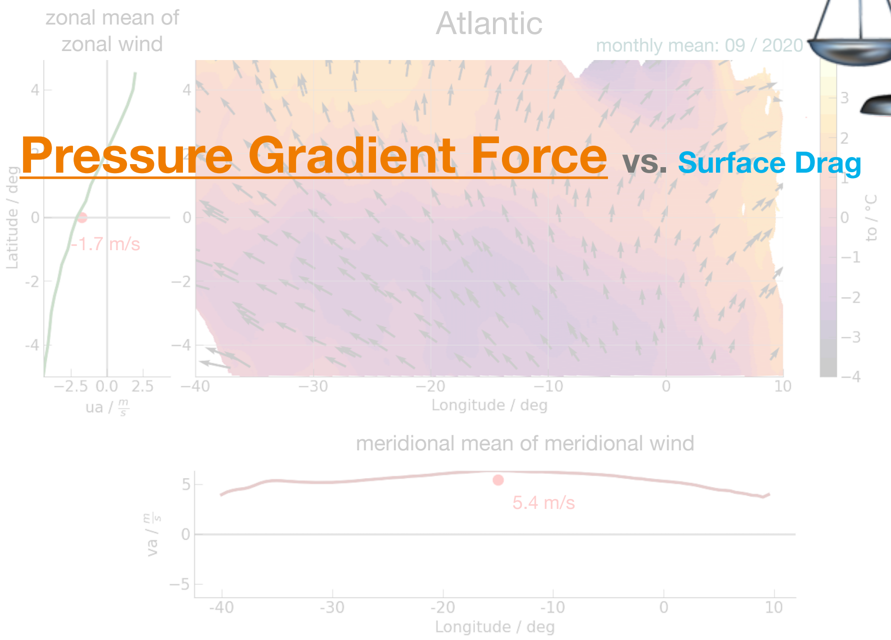
Pressure Gradient Force vs. Surface Drag

Type 2/2: Cross Equatorial Winds

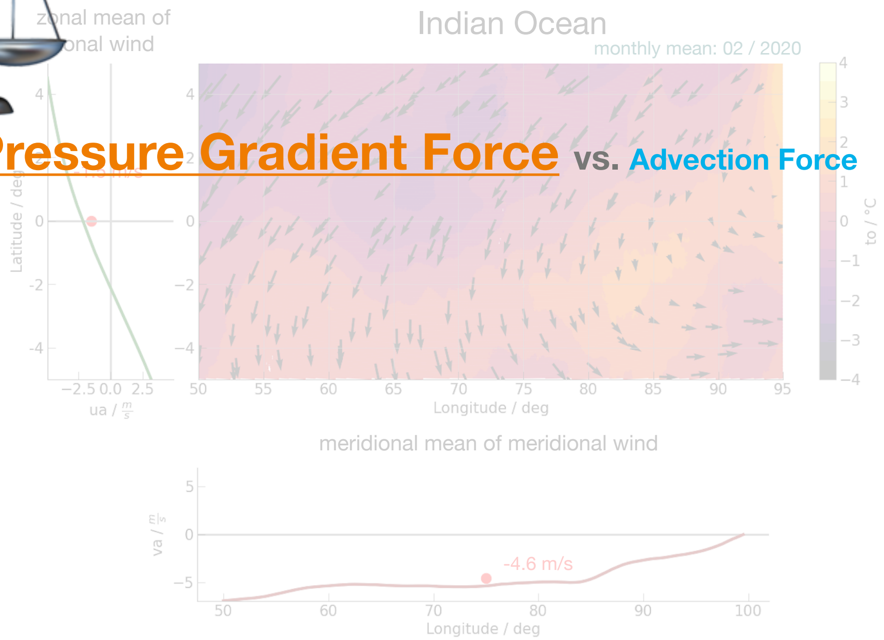




Type 2/2: Cross Equatorial Winds



Pressure Gradient Force vs. **Surface Drag**



Pressure Gradient Force vs. **Advection Force**

Conclusion

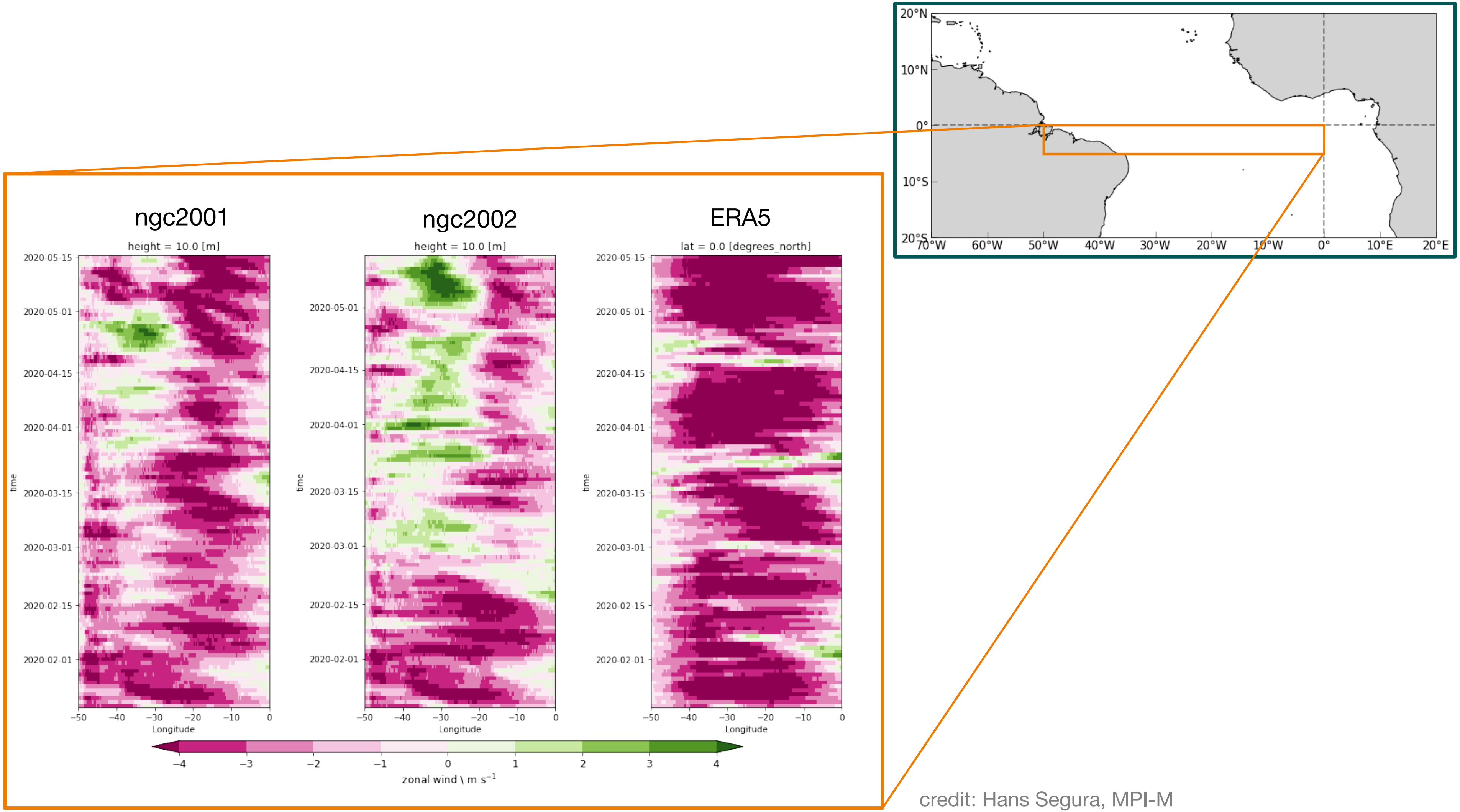
A. We identify two types of equatorial boundary layer winds in ngc2009:

1) **Zonal Wind Belt**
2) **Cross Equatorial Winds**

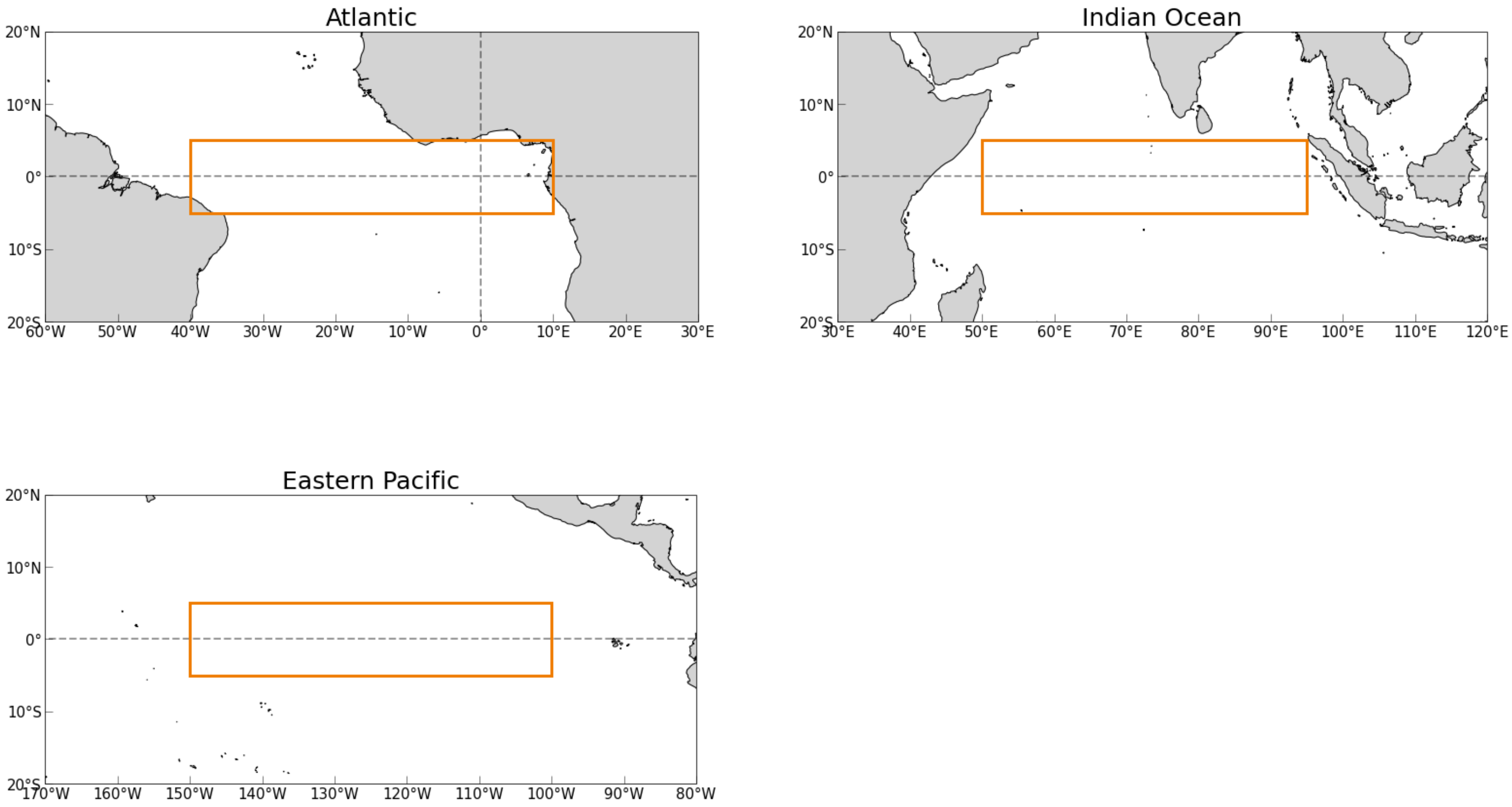
Wind Type	Atlantic	Indian Ocean	Eastern Pacific
Zonal Wind Belt:	Winter	Spring, Autumn	All year
Cross-Eq. Wind:	Spring, Summer, Autumn	Summer, Winter	X

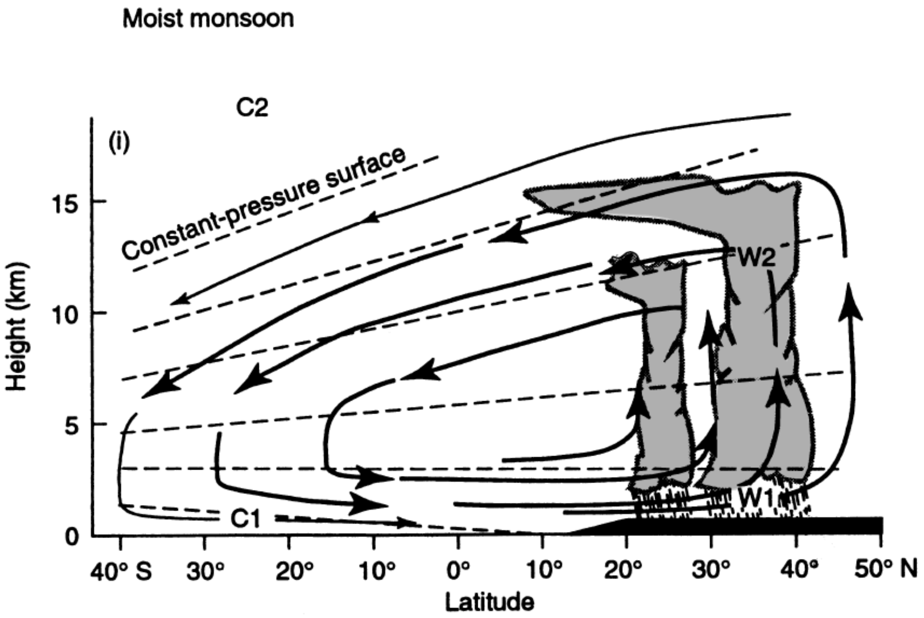
B. **Pressure gradient force dominates the wind balance.**

Any
Questions ?



credit: Hans Segura, MPI-M


Atlantic
20°N
10°N
0°
10°S
20°S
60°W
50°W
40°W
30°W
20°W
10°W
0°
10°E
20°E
30°E
Indian Ocean
20°N
10°N
0°
10°S
20°S
30°E
40°E
50°E
60°E
70°E
80°E
90°E
100°E
110°E
120°E
Eastern Pacific
20°N
10°N
0°
10°S
20°S
170°W
160°W
150°W
140°W
130°W
120°W
110°W
100°W
90°W
80°W



Holton: *"An Introduction to Dynamic Meteorology"*, 4e, (2004), p. 381

ICON - ICOsahedral Nonhydrostatic

A. Non-hydrostatic model on global domains

B. Good conservation properties (mass and energy)

C. Unstructured grid originating from an icosahedron

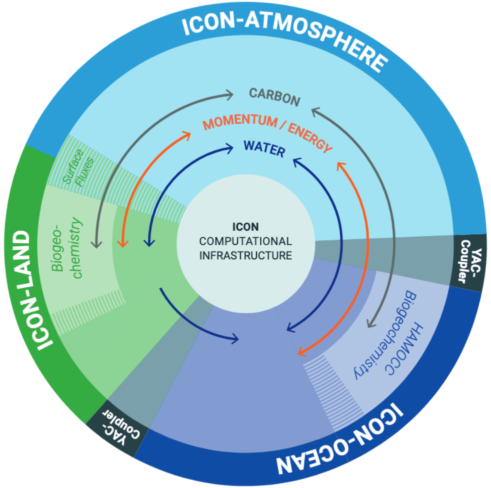
D. R02B09: 5km (square root of mean cell area)

E. Total number of grids in R02B09: 20 971 520

F. 90 levels: top at 75km with 400 m, bottom with 25m

G. NextGEMS cycle 2 run:

➛ 2-year simulation output: 01/2020 – 02/2022



Hohenegger et al. (2022)