Evolution and energetics of Tropical Instability Waves during 1996-2000 (2)

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Instability Mechanism

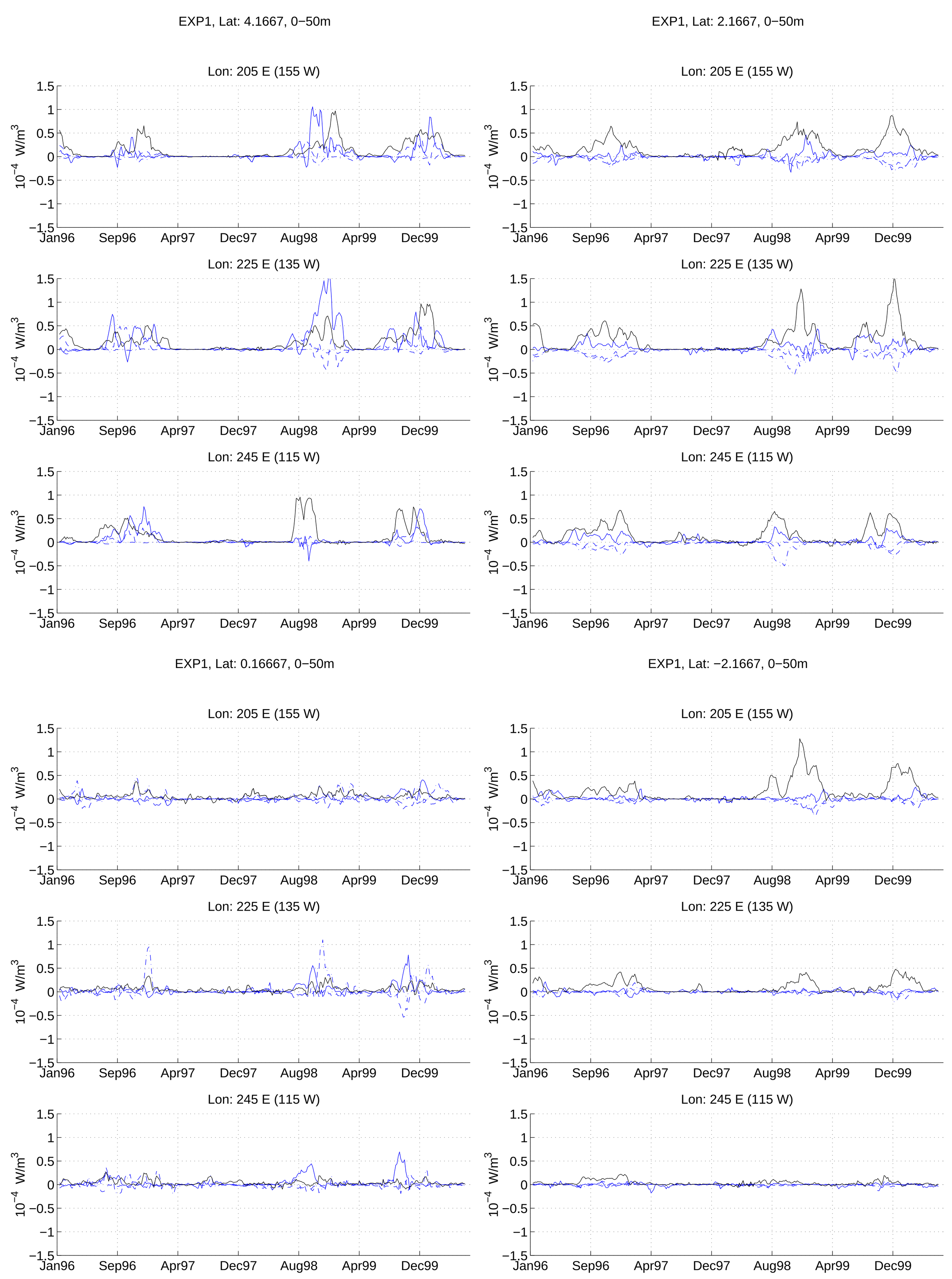

Fig. 1: Time evolution of different terms of the perturbation kinetic energy (PKE) in the EXP1 experiment at four latitudes : 4°N, 2°N, 0°, 2°S. The values have been averaged between 0 and 50 m depth and in a 10°-wide longitude band centered on 155, 135 and 115°W, respectively. (Blue) Barotropic conversion: $-<u'v'>U_y$ (plain line), $-<v'v'>V_y$ (dashed line) and $-<u'w'>U_z$ (dashdotted line). (Black) Baroclinic conversion: $-g<\rho' w'>$.

Instability waves north of the equator and role of the NECC: At 130-140°W of longitude, the barotropic conversion (dominated by $-<u'v'>U_y$) is maximum at about 4°N within the cyclonic shear between the South Equatorial Current (SEC) and the North Equatorial Counter-Current (NECC). The importance of the barotropic conversion varies in time and in longitude: (1) similar amplitudes are observed further west (155°W), but further east (115°W), the barotropic term no longer prevails and the TIWs mainly derive their energy from baroclinic instability; (2) at 155°W of longitude, the barotropic conversion is very weak during the 1996-1997 TIWs season, when it is large in 1998-1999 and 1999-2000.

Relative importance of the baroclinic instability north of the equator: The baroclinic conversion also contributes to the eddy energy production at 4°N. At that longitude, the amplitude of BC is similar to that of BT. At 2°N, the TIWs mainly derive their energy from baroclinic instability. (Fig. 1). Although, the dominance of the baroclinic terms is observed at 155 and 115°W and during the three TIWs season (that is 1996-1997, 1998-1999 and 1999-2000), it is also subject to large interannual and spatial variability (Figs. 1 and 2).

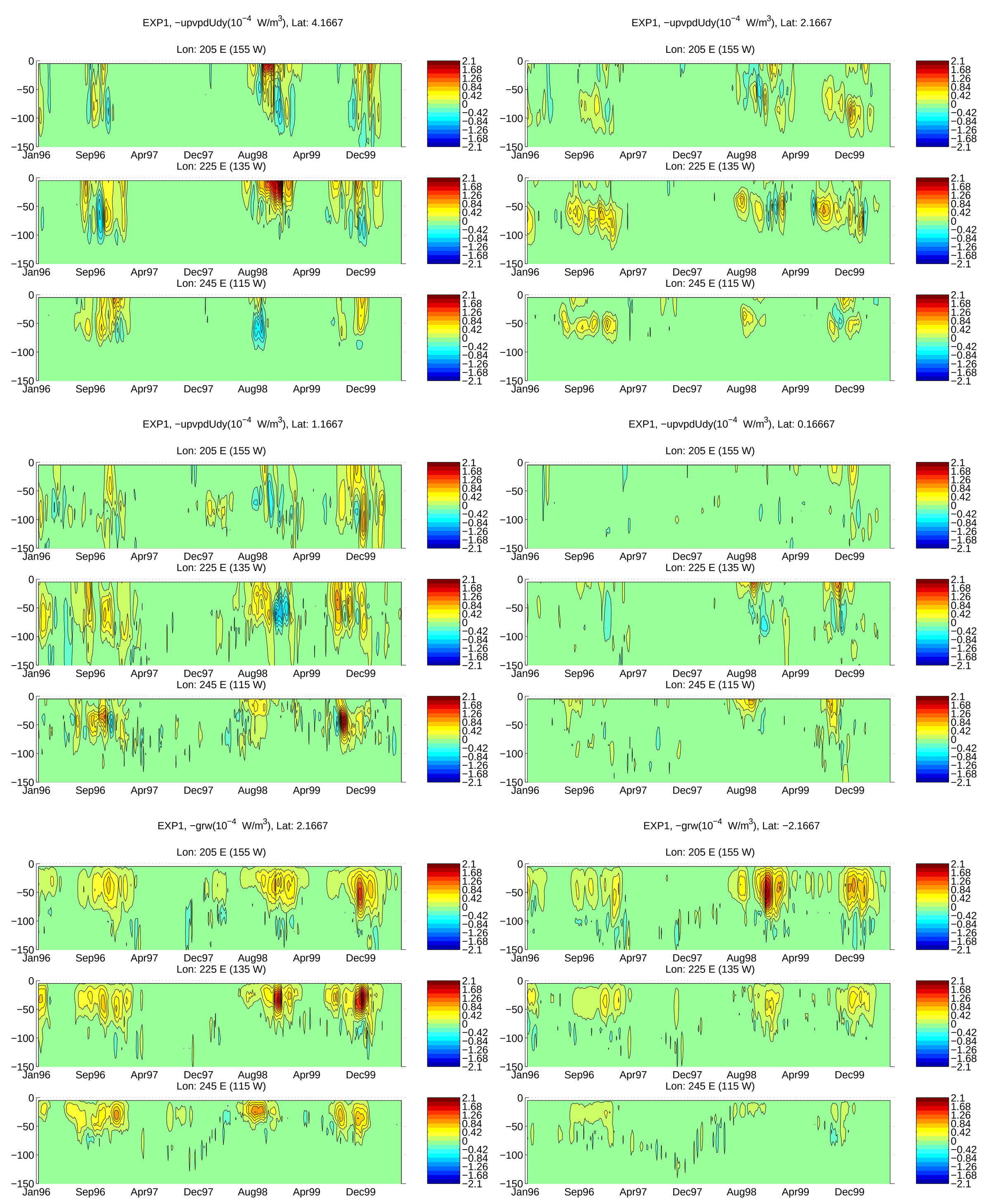

Fig. 2: (Upper panels) Depth-time plots of the barotropic term $-<u'v'>U_y$ at 4°N and 2°N. (Middle panels)Depth-time plots of the barotropic term $-<u'v'>U_y$ at 1°N and at the equator. (Lower panels) Depth-time plots of the baroclinic term $-g<\rho' w'>$ at 3°N and 3°S.

Shear between the SEC and the EUC: The maximum of the term $-<u'v'>U_y$ is located in surface at the equator and at deeper depth when moving northward (Fig. 2) which shows that both the SEC-EUC shear and the SEC itself play a role in the generation of TIWs just to the north of the equator. The maximum of $-<u'v'>U_y$ is larger at 2°N than at the equator. Compared to the observations, the TIWs are too weak along the equator, especially in 1996 when $-<u'v'>U_y$ is almost zero, which suggests that the barotropic energy production that arises from the shear within the SEC itself at the equator is too weak in the model.

Instability waves south of the equator: South of the equator, the barotropic term is negligible and the baroclinic instability is the main source of energy to the fluctuations (Fig. 1). The eddy energy production is larger in the western than in the eastern basin.

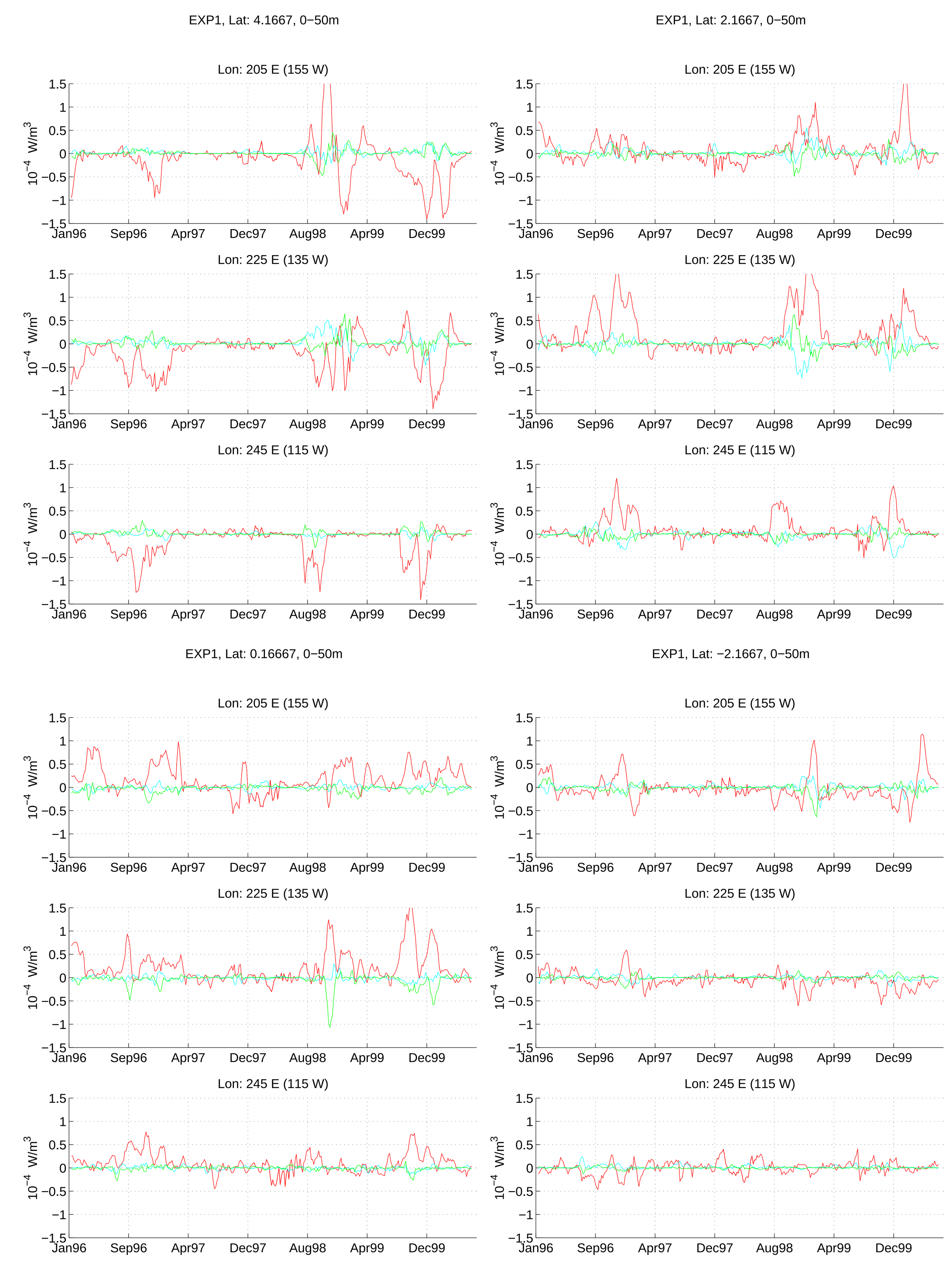

Fig. 3: Same as Fig. 1 for other terms of the perturbation kinetic energy. (Red) Eddy pressure fluc divergence, $-[<u'p'_x>+<v'p'_y>+<w'p'_z>]$. (Green) Advection by eddies $-[u'(PKE)_x+v'(PKE)_y+w'(PKE)_z]$. (Cyan) Advection by mean $-[U(PKE)_x+V(PKE)_y+W(PKE)_z]$.

Eddy pressure flux divergence: The eddy pressure flux divergence radiates energy away from the production region, that is from 4°N toward the equator (Fig. 3). This term is as important as the other terms.

Sensitivity to the wind stress-field The eddy energy production is larger when the ECCO wind-stress field is used. However, many of the previous conclusions are robusts (Fig. 4). Indeed, the baroclinic instability remains dominant at 2° on both sides of the equator, the barotropic instability at and just north of the equator is still weak, and the radiation of energy keeps the same sign. The main differences occur at 4°N: the importance of the NECC remains true but the variability previously observed is less striking. Particularly, the barotropic instability is large at 115°W and in 1996/1997 at 155°W.

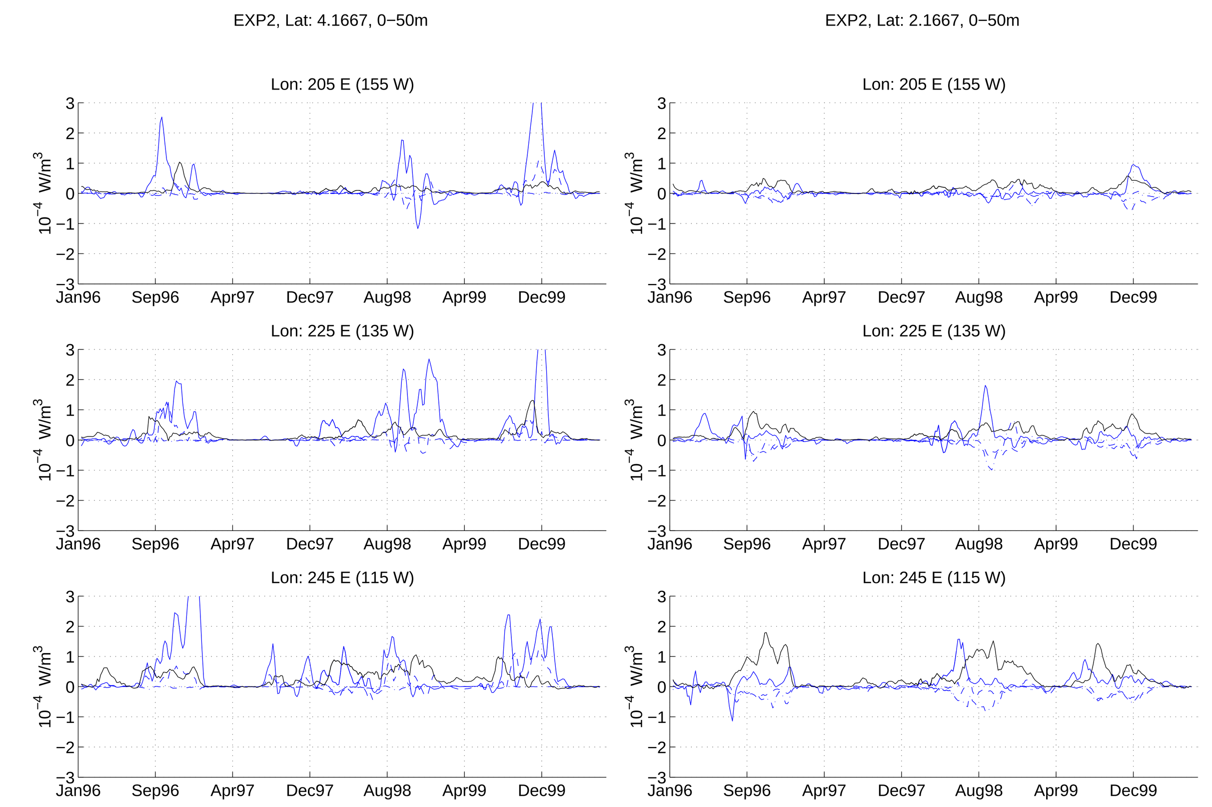

Fig. 4: Same as Fig. 1 but for the EXP2 experiment. The values are plotted at 4° and 2°N.

Conclusion and perspectives

- The main characteristics of the TIWs in the models are in good agreement with the observations. The variability is not enough energetic when the NCEP wind-stress field is used and is too energetic when the model is forced with the ECCO wind-stress. Increasing the model resolution does not significantly improve the model solution. As the wind is crucial for modelling the tropical oceans and the Tropical Instability Waves, those results rise the necessity of developping data assimilation in high resolution model.
- At about 2° on both sides of the equator, as well as at 4°N, the perturbations gain their energy through baroclinic instability. Just to the north of the equator and at 4°N, barotropic instability prevails. The model clearly shows the importance of the NECC in the eddy energy production. However, its influence is subject to spatial and interannual variability which could explain that, in the litterature, a consensus has not been found on the role of this current. The SEC and the EUC appears to be involved in the eddy energy production just to the north of the equator, but the barotropic instability at the equator arising from the shear in the SEC itself is weak and could explain the weakness of the TIWs along the equator in the models.
- The next step will consist in following an instability wave during its propagation across the basin in order to determine the mechanism that induces the growth of this wave, the mechanism that maintains this wave during its propagation and finally the reason for its death.

References

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