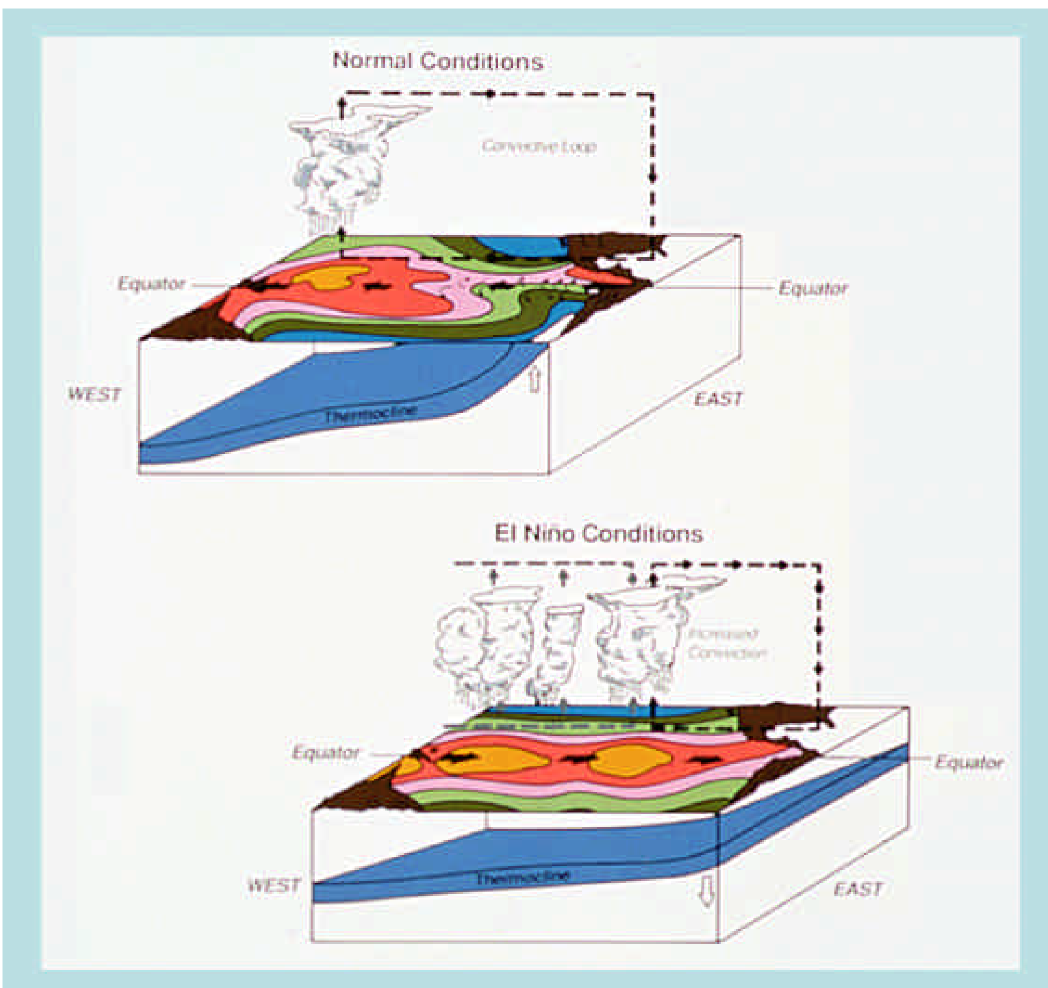
Convection is poorly modeled in all present GCMs. The result is their generally cold bias at the Polar Regions; the cold tropopause; inadequate stratiform cloud formation; poor mid-latitude storm track formation; etc. Present GCMs are ineffective tools to assess such convective response. GCMs also make little attempt to deal with the upper stratosphere and mesosphere, which, it seems should also be important.

Below are graphical illustrations of the fundamentally different ocean conditions before an ENSO Warm Event: the Warm Pool is reinforced by the Hadley Circulation dependent Equatorial Easterlies – formed in the Equatorial Atlantic, off Africa, and continuing across the Atlantic, Caribbean and Gulf of Mexico into the Pacific Ocean. Then, once these easterlies 'relax', or reverse, a Kelvin wave results from gravitationally forced 'settling' of the sea surface, and displacement of subsurface water mass along the equator. Onsets of El Niños are also linked to Madden-Julian waves originating in the eastern Indian Ocean that can mitigate the Equatorial easterlies.

The eastward progression of M-J waves brings west-wind anomalies into the western Pacific Warm Pool. It is these west-wind anomalies, or calms, that trigger Kelvin waves in the Pacific Ocean which propagate eastward. As the warm surface water and Deep Convection clouds move eastward, more heat is trapped, and the SSTs rise – leading to more Deep Convection – indicated by the progression of cloud towers in the diagram. As the surface height decreases, the thermocline shoals in the west, and deepens in the east.



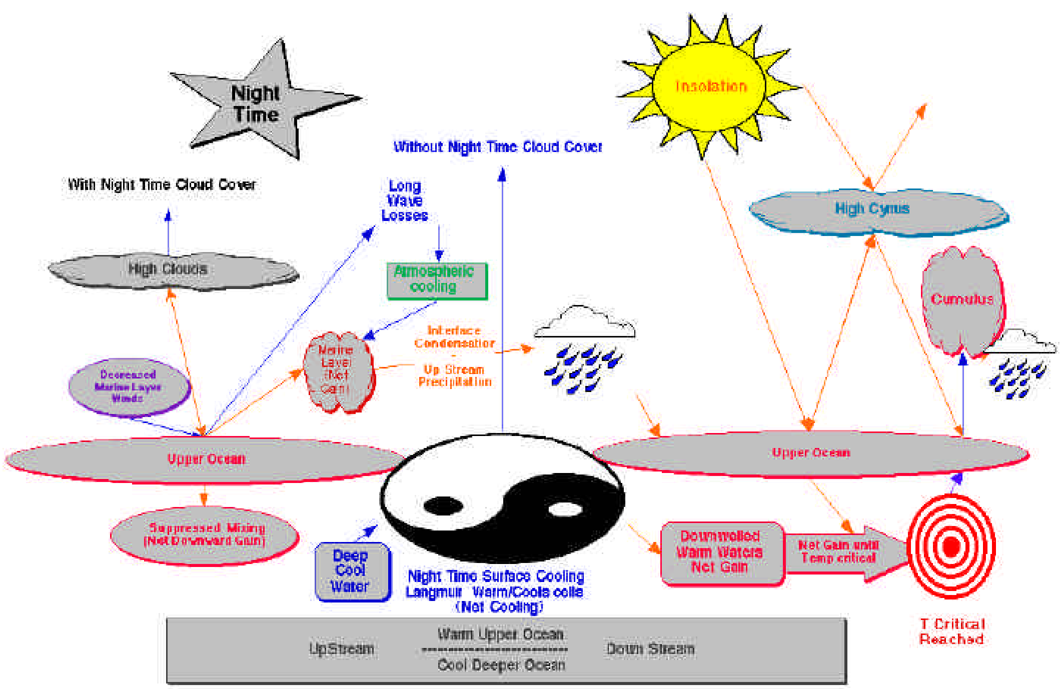
Similar upper ocean warming creates tropical disturbances, including tropical cyclones, typhoons and hurricanes within well known locations such as the western coast of Mexico; the eastern Tropical Atlantic, Caribbean and Gulf of Mexico, as well as the western Pacific region including the Philippines. There are two characteristics of this that are particularly interesting.

A key factor in convection that would mitigate the effects of additional radiation forcing is the work performed by the Hadley Cells.

Equatorward directed tropical surface easterly winds extend over approximately fifty percent of the globe's surface. Their main role is accumulation in the boundary layer of heat, moisture and momentum from the underlying oceans and land surfaces. Over the tropical Pacific Ocean the Trade Winds transport heat and moisture westward; the underlying wind-driven current is warmed by solar radiation and a Warm Pool is formed in the surface waters of the equatorial Western Pacific Ocean. The accumulated sensible and latent energy of the equatorial boundary layer air is released (actually converted to potential energy) in the deep tropical convection associated with the Intertropical Convergence Zone and tropical disturbances. The warmest sea surface temperatures and deepest thermocline are in the Warm Pool and provide abundant energy for massive buoyant convection cells reaching to the tropopause.

A fact that is often poorly recognized is that there are symmetrical, if opposite forces operating in the Indian Ocean. The wind forced upwelling of cold water off the coast of Ecuador and Peru, that form the Humboldt Current and it’s Equatorial extension, and the upwelling that takes place off the Horn of Africa as a result of seasonal winds feeding the Indian Monsoon – both contribute to the opposite directed equatorial SST gradients in the Indian and Pacific Oceans, and related atmospheric subsidence over the western Indian Ocean and eastern Pacific Ocean. Under normal conditions surface pressure is lower over the Warm Pool and higher over the eastern Pacific and western Indian Oceans. The variations of which result in the Southern Oscillation, defined in the late 1800s, and tracked.

The progression of M-J waves over the Warm Pool and their propagation eastward then can trigger El Niño, and also the weakening of the Walker Circulation and the weakening of the reverse circulation over the Indian Ocean. Then follows high rainfall over coastal Ecuador and northern Peru as well as along eastern Africa, from the Nile watershed as far south as the Horn of Africa - but later in the cycle. The consequence of the Lower Southern Oscillation Index values - lower Pressures in Darwin, Australia – will release the Warm Pool's eastern limits – so that convection towers proceed westward, into and across the Indian ocean, as well. This promotes high rainfall levels in the east African Highlands, and thus Flooding along the Nile, and sometimes more southerly East African watersheds.



Meanwhile, there are distinctly different Day-Night dynamics, given the solar input by day, and IR losses at night, that with the earth's rotational influences, affect downstream processes. Energy charged Convection Towers are 'ejected' in the afternoon, leading to downstream heat trapping, as IR emissions from the ocean surface are reflected downward in the adjacent nighttime.

The result is a continuous eastern progression of warm Surface temperatures in the Pacific Ocean, as these diurnal patterns progress, under the relaxed equatorial easterlies. Thus the waves move further eastward until the energy of the boundary layer is not sufficient to sustain buoyant convection - at about the 28C SST margin. Within the eastern Tropical Pacific normal circulation patterns tend to store surface heat within the Panama Bight, and northward along the western Mexico coast – with a maximum energy content just off Acapulco - where any eastward cloud progressions are reinforced – and massive Tropical disturbances are generated. These typically flow northwest – off toward the Hawaiian Islands - but if an ENSO Warm Event has already affected coastal and Gulf of California SSTs, these convective cells can head north, along the coast, often inundating sectors of Baja California, or wander up the Gulf of California, into the southwest desert of the USA, depending upon SSTs. Devastating events occur wherever they make landfall.

Importantly, Deep Convection does not take place until the underlying sea surface temperature reaches about 28C. Over land the humidity of the boundary layer air is generally less and so a similar equivalent potential temperature (representing the sum of sensible, latent and potential energies) of the boundary layer air is achieved at a higher temperature. Over equatorial lands, particularly where rain forests occur, in summer the diurnal solar heating of the land (and rapid transfer of energy to the atmospheric boundary layer) generally releases buoyancy of the boundary layer air during the afternoon. Over the oceans it is large-scale dynamic convergence that is required to release the buoyancy, because over water diurnal temperature cycle is limited; clouds absorb solar radiation (they have high albedo) during the day but strongly emit IR, so cloud tops strongly cool overnight, enhancing instability of the lapse rate and buoyancy. The overnight destabilizing accentuates convection over water in early morning.

Tropical thermodynamics is dominated by the absorption of Solar Radiation by the underlying land and oceans; heat and moisture are transferred from the underlying surfaces to the atmospheric boundary layer; buoyant deep tropical convection transforms the sensible and latent heat to potential energy to offset atmospheric cooling, both in the tropics and the middle and higher latitudes, where small changes in LW will be lost in the circulation and convection processes,

The point of this comparative information is that a slight change in the LW radiational forcing will be largely lost in the circulation and convection processes. A small change in LW radiation at the surface over the oceans must raise the ocean temperature (i.e., change the surface fluxes of latent and sensible heat) before it can have any effect on the atmospheric circulation and will take a long time before its impact is noticeable. This is why it is unlikely that the sudden increase in equatorial SST in the mid-1970s can be attributed to greenhouse forcing; it is more likely to be due to a small change in the ocean circulation - an internal variability of the climate system denied by IPCC.

As well, the temperature of the troposphere above the mixed boundary layer is locally independent of the underlying surface temperature. The proof of this is the existence of the trade wind inversion separating the moist well-mixed boundary layer from the overlying dry subsiding air. The temperature of the troposphere is governed by the equivalent potential temperature of the ascending air in the updrafts of deep tropical convection (in the ITCZ and tropical disturbances). If the tropical tropospheric air cools it encourages more convective overturning. Compensating subsidence (the dry adiabatic lapse rate is steeper than the atmospheric lapse rate) will warm the atmosphere until buoyancy in the updrafts is lost. In steady state we have (largely) the oceans providing energy, and thus buoyancy, to the overlying boundary layer air and LW radiation cooling of the atmosphere modulating the mass flow in the deep tropical convection.

Thus, over a large part of the globe (at least that part influenced by the Hadley Cells - more than fifty percent) the temperature of the troposphere is governed not by local radiation processes but by the boundary layer temperature at which buoyant convection takes place in the ITCZ and tropical disturbances. It is no surprise, therefore, that satellite and radiosonde estimates of tropospheric temperature do not show evidence of warming over the past 30 years whereas near surface thermometers do.

We also have reason to be skeptical about any handwaving arguments postulating 'positive feedbacks' from cloud and moisture dependence on atmospheric temperature. Any changes are linked to the strength of the Hadley Cell circulation and the mass flow in the deep tropical convection. Increased moisture in the boundary layer is at the expense of temperature. A tendency for warming of the underlying surface as a result of reduced net LW radiation at the surface due to overhead clouds, in the downstream flows from the deep convection cells. Thus, the direct impact of increased concentrations of CO_2 and other anthropogenic GHG will be strongly modulated by both heat and moisture exchange with the overlying boundary layer.

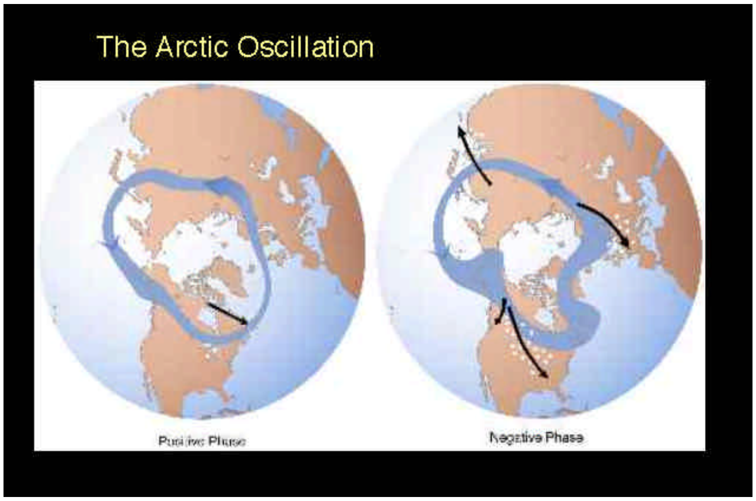
As explained above, convection occurs when the equivalent potential temperature of the boundary layer reaches a critical value for which ascending air can rise buoyantly to and often well into the tropopause. Thus, the slight increase in heat and moisture exchange between the surface and boundary layer will not raise the equivalent potential temperature required for buoyancy but will increase the mass flow within the convective processes. We see this relationship during El Niño events. The generally warmer SST generated through natural variability of the climate system of tropical waters of the Pacific Ocean enhances the energy exchanges between the upper ocean and overlying boundary layer of the atmosphere. The enhanced mass flow of deep tropical convection is inferred from the enhanced atmospheric angular momentum during these events.
As with temperature, the atmospheric moisture of the troposphere is only weakly linked to the temperature and humidity of the underlying boundary layer. The increases are more related to the upstream deep convective processes.

Atmospheric scientists have used the one-dimensional (globally averaged annual mean) radiation models as useful constructs for estimating the magnitude of the various radiation terms of the earth's energy budget. In doing so they have unwittingly given emphasis to the radiation processes and averaged out various important processes including convection, ocean and atmospheric circulation and time varying changes in energy storage of the ocean and cryosphere. This one-dimensional model has become the basis for arguing the 'radiation forcing' concept, that is simply inadequate as a basis for climate forecasts.

In a general sense GHG and LW radiation are important in the energy processes of the climate system. But the latter are not 'in balance' as postulated by the IPCC. Considering the climate system, there is excess solar radiation over the tropics that is largely absorbed by the ocean surface layers. The atmosphere only knows of this solar radiation through accumulation and heating of the surface layers. Heat and moisture are exchanged with the overlying boundary layer at a rate governed by their respective temperatures and the humidity of the air. At the same time the LW radiation loss from the troposphere is modulated by the emissions of LW radiation from the atmospheric GHG (predominantly water vapour but also CO2, methane, etc. Heat and moisture accumulating in the tropical boundary layer are converted to potential energy in the buoyant updrafts of deep tropical convection, and any condensed water vapour returns to the surface as (warm) precipitation.

Heat becomes available in the tropical troposphere because there is an overturning mass (Hadley Cells) and a difference between the lapse rate of the ascending air (moist adiabatic within deep convection) and the subsiding air (dry adiabatic away from the deep convection). The rate of heating of the tropical troposphere by the Hadley Cell circulation is sufficient to compensate for local LW radiation cooling (as a result of atmospheric GHG) and for export to the extratropics by the atmospheric circulation, necessary to compensate for the net radiation deficit over those parts of the globe.

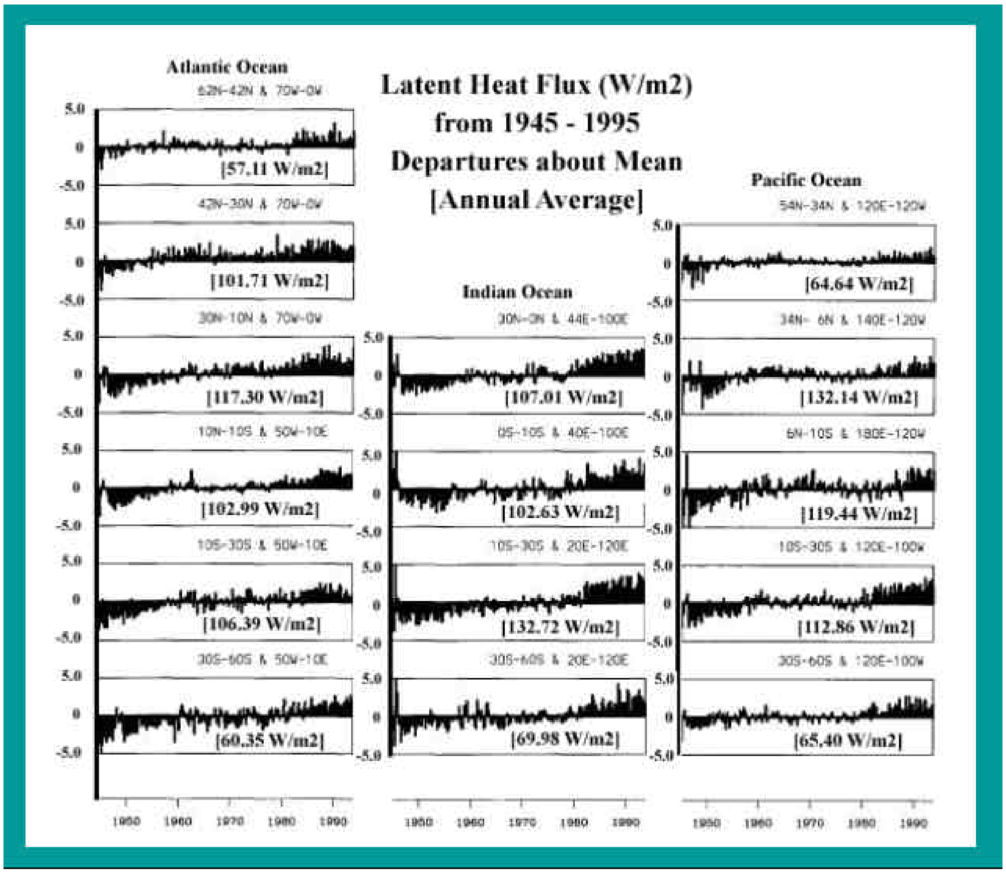
The role of Polar Subsidence has yet to be accounted for in our account for temporal dynamics. Within the Polar Regions, the net heat loss is huge, and the resulting massive subsidence of arriving moist air helps drive the Pole to Equator recirculation, and should be considered equally as important as equatorial processes, as pointed out by empiricists such as Professor Marcel Leroux, and others. Below, you can see that one of the characteristic changes associated with the Arctic Oscillation is the formation of another (a 3rd) High-Low pair, and potential for deeper intrusions of the Jet Stream, and MPHs, as we observed in 2002-2003, 1953-54, and early in the 20th century.



It is also important to recognize that the Southern Hemisphere comprises an immense water surface, as well as a central continental feature around which the ocean circulation and atmospheric dynamics and their interactions can, and do affect Global climate dynamics, via deep water as well as atmospheric motions. Amongst these dynamics are those Polar Subsidence processes, (Mobile Polar Highs, or MPHs) which, due to the rather limited terrain interference, if powerful enough, can be transferred across the equator, to interact with Asian Monsoon dynamics in Asia, or South America's highland climate dynamics as they interact with the Andean orography.

These atmospheric subsidence processes also contribute to surface winds, hence ocean circulation speeds, as well as surface forcing that can account for massive heat transport, out of the southern Hemisphere, into the northern regions, either into the North Pacific Ocean, or into the Indian Ocean's monsoon system.

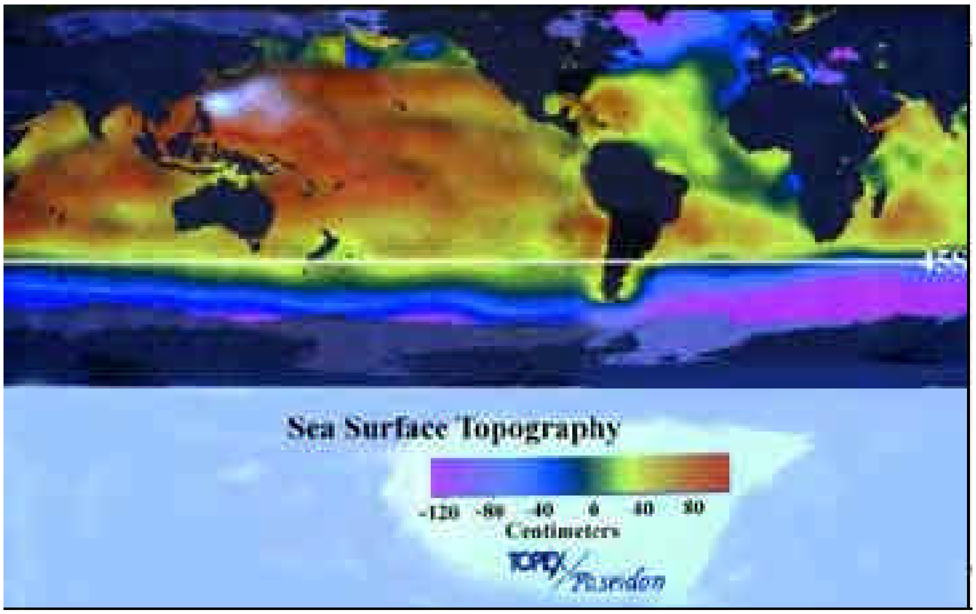
The COADS surface wind speed departures for a recent 50-year period show a rather continuous increase in the latent Heat Flux, as a function of these surface winds. It should also be noted that the COADS surface wind speed departures for these same regions of the Globe have recently been extended back into the 17th Century, and that they tend to exhibit parallel patterns, despite the energy differences at each latitudinal stratum. They also exhibit cyclical dynamics, and they appear to have reversed the 50-year trend (seen below) in the 1997-98 Climate Regime Shift, recorded in the AO, PDO, SOI and the Russian ACI.



The important message here is that a fifty year observational series is not adequate to infer future Climate Change. Even more discouraging, despite their amazing information content, are the satellite remote sensing observations, only available in some cases back to 1979, and in most, less than a decade.

The insights that such short term observations provide are more than ample reason to keep them coming – until they do provide Climate Scale information. For example, TOPEX sea surface height records from the 1990s (as below) indicate a massive deficit in sea surface height for the Southern Ocean. As well, they document the expected increased surface heights from the Equatorial and North Pacific Ocean warming since 1976, the start of the most recent warm epoch of the Dipolar PDO, AO, etc.

Another factoid that recent satellite measurements of sea surface height provide is about the volume of rise of the warmer regions being about equivalent to the massive deficit found in the polar regions, particularly the vast Southern Ocean.



The concept that we actually have accounted for each and every major contributor to the Earth's Climate Energy Balance in the present GCM efforts is simply not true, given the few examples provided herein.

Certainly, atmospheric GHG are important for modulating the LW radiation component of climate energetics. But, this 'forcing' role is only one of several components and their interactions that contribute to long term climate variability. Clearly, there is more to obtaining measures of Global Climate than simplistic parameterized models that take few or none of these major system dynamics into direct account. It is simply wrong to over-emphasize this as an important 'man-made' component at the neglect of the many factors contributing to the natural variability of the climate system.

These are the joint concerns and opinions – merged with my lecture imagery and notes with a descriptive narrative from William Kininmonth.