The Importance of COADS Winds for Understanding Climate Change

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A quarter century ago S. Manabe and R. Weatherald published a one dimensional computation of surface warming from a doubling Of CO_2: 3°C was their result. It was an interesting and useful result; but no one believed that all other factors remained constant or that all the feedback loops canceled.

A few years later an error bar of 1.5°C was added by a U.S. National Academy panel. It was a guess. Today the Intergovernmental Panel on Climate Change (IPCC) estimate is about the same and is being used to represent what is likely to happen in the real world. Does this mean that all other factors really do remain constant or that all the feedback loops cancel each other? Or is something wrong?

The first IPCC report was published four years ago and was accepted by most political authorities as gospel. For example, in 1992 the five democratic presidential candidates held a televised debate before the New Hampshire primaries. All five agreed that to reduce greenhouse warming effects the U.S. should commit to limiting CO_2 emissions by the year 2000 to 1990 levels. Two of the candidates called this, “the most important issue of our time.”

The U.S. government has now made such a commitment. The enormous costs involved will impact such social needs as health care, education and child care, but, they have been convinced that there is no other choice if we are to avoid catastrophic climate changes, such as sea level rise and desertification of the American mid-continent. Costly legislation is now before the U.S. Congress to implement this policy, including using the tax code to force conversion of power generation from coal, which we have in vast reserve, to natural gas, which we have in limited reserves.

In the real world, we know that other factors are not constant. A look at observed behavior of climate tells us that changing strength of the atmospheric circulation is a very robust feature of climate change, and many factors are strongly influenced by wind strength. For example, evaporation over the ocean is proportional to wind speed and amounts to about 100 W/m^2. Only a 4% *decrease* in wind would decrease evaporative cooling of the ocean by 4 W/m^2, about equal to doubling of CO_2 thus adding to surface warming by a factor of two.

On the other hand, an *increase of* surface wind by 4% would increase evaporation by 4 W/m^2 and just about cancel the greenhouse surface warming. The additional heat and moisture extracted from the ocean would be added to the mid-troposphere where rain is formed. If the increase in evaporation is more than 4%, it more than balances the radiative effect of CO_2 doubling and the ocean is cooled, while the atmosphere is warmed more strongly.

What does the record show? Will the wind blow stronger or weaker in an enhanced greenhouse world? Figure 1 shows the strength of the surface wind over the global tropics, 30°N to 30°S, for more than half a century. The first vital question: is the trend upward or downward and how does the magnitude compare with the 4% corresponding to CO_2 doubling? The graph also shows the main forcing factor for the Hadley Circulation, deep tropical convection, which heats the mid troposphere and transports mass upward. Since we have only about two decades of direct satellite observation of tropical convection I use as a proxy, the area of ocean warmer than 29°C.

This COADS record of the last sixty years says several things:

1. The trend (in surface wind and the index of tropical convection) is up. Other things do not remain constant.
2. The changes are large and strongly correlated with each other (both the size of the warm pool and the strength of the Hadley Circulation). The mean wind speed has increased by about 25% to 6.5 m/s and evaporation by a similar proportion, several times larger than the 4 W/m^2 associated with CO_2 doubling. The small arrow representing 4% is shown on the chart for comparison.
3. Contrary to the usual notion that the ocean and atmosphere cool or warm in the same direction, the opposite is true. Increasing wind speed extracts more heat by evaporation from the ocean and gives it by condensation to the atmosphere. The ocean as a whole is cooling, even though the size of the warm pool has been increasing. This infers that ocean circulation plays an important time variable role in maintaining the warm pool. COADS tells us that the wind increase has been greatest in the Northern Hemisphere during its winter. The Northern Hemisphere oceans show cooling. The Southern Hemisphere wind increase is less and sea surface temperature has warmed slightly.

These trends cannot continue indefinitely because a cooling ocean must eventually overcome a growing warm pool. We have here the essential element of an oscillating system, negative feedback and delayed response.

How is circulation strength related to rainfall over continents? Common sense would say that more evaporation and more moisture carried inland by stronger circulation means more precipitation inland. That is also what the record shows. The best and longest record for Central North America is the level of the Great Lakes. Over the last century and one half it has gone from high levels in the 1870s to low levels during the 1920s and 30s to high levels again in the 1980s, parallel to changes of wind strength. We call the mid-continental drought of the late 1920s and 30s the “dust bowl”. By contrast, the 1980s and 90s have had much more rainfall.

In this revised scenario of increasing wind strength both of the greenhouse threats are gone: sea level does not rise because the ocean is losing heat, not gaining heat and snow on land is increasing, not decreasing. Mid continent desertification is related to weak rather than strong circulation.

We are left, however, with a big question. How long can the size of the warm pool and the circulation strength continue to increase while the global ocean is losing heat? It cannot continue indefinitely. Ocean transport of heat into the warm pool is necessary to maintain its large and increasing size and this must deplete heat storage at higher latitudes. COADS data shows that the last peak in circulation strength was about 1870 and when the trend changed, it was quite abrupt. I suggest that forecasting the end of the present increasing trend, with its regional climate changes, is the pressing challenge facing the climate research program.

Forecasting the size of the warm pool and strength of the circulation is the heart of the problem. Improving the surface wind data set will be a big help.

There are several questions that need attention:

Why don't GCM's give the right answer? How should they be improved?

A first order answer to this question is shown by the dashed line in Fig. 1 which represents the lowest level wind (990 mb) in G. Lau's four decade simulation using observed global SST. It says that even the expensive GFDL model does not simulate change on this time scale. There is no significant trend in the model results. Parameterization of tropical convection must be improved to simulate correctly the last half century before we can accept its prediction for the coming century.

How is this dynamic feedback loop related to the cloud/radiation feed back?

A first order answer is given by V. Ramanathan who used ERBE data to conclude that the cloud feedback is negative, together with other work based on COADS and other data that show that cloudiness has been increasing over the last half century. Both results would add to the negative feedback of the dynamic wind feedback loop but more investigation is needed.

How good an index is the size of the warm pool for representing the amount of deep convection?

We now have about 3 decades of outgoing longwave radiation (OLR) and we should be able to compile a satellite record of deep convection for comparison.

Should we believe the wind record that yields these startling results?

Some would say no. Included in the ocean wind record are many possible biases that are difficult to evaluate. That is what this workshop aims to accomplish.

The first order question is: Is the wind trend up, down or zero? I believe that the trend is up and that the change of recent decades is more than 4%. If so, the greenhouse "threats" of sea level rise and mid continent audity have been grossly exaggerated.

As evidence of increasing circulation strength Figs. 2 and 3 show the ocean basin wide change in surface pressure and vector wind from 1950-70 to 1970-90 (from COADS). The coherence of the changes in pressure field and wind field is conspicuous.

Critics of the conclusion outlined above point to the many defects of COADS. Many are real. Many are exaggerated. The governing consideration is that we have no alternative description of the behavior of the global climate system over the century time scale. This description, though incomplete, is in glaring contrast to current assumptions about greenhouse warming and climate change on which costly policies are based. An important step was recently taken by Prof. James O’Brien at Florida State University. For the tropical areas for which his group produces the reference wind stress maps for TOGA he has extended the record backward in line to 1930, also incorporating more sophisticated quality control, interpolation and bias corrections such as has been suggested by C. Ramage and others. Figure 4 reflects this data set for comparison with Fig. 1. The trend is up! The change is large! All of the considerations outlined above apply!

Figure 1:

COADS wind vs. SST>29 deg C coverage
30°N-30°S,0°-360°E

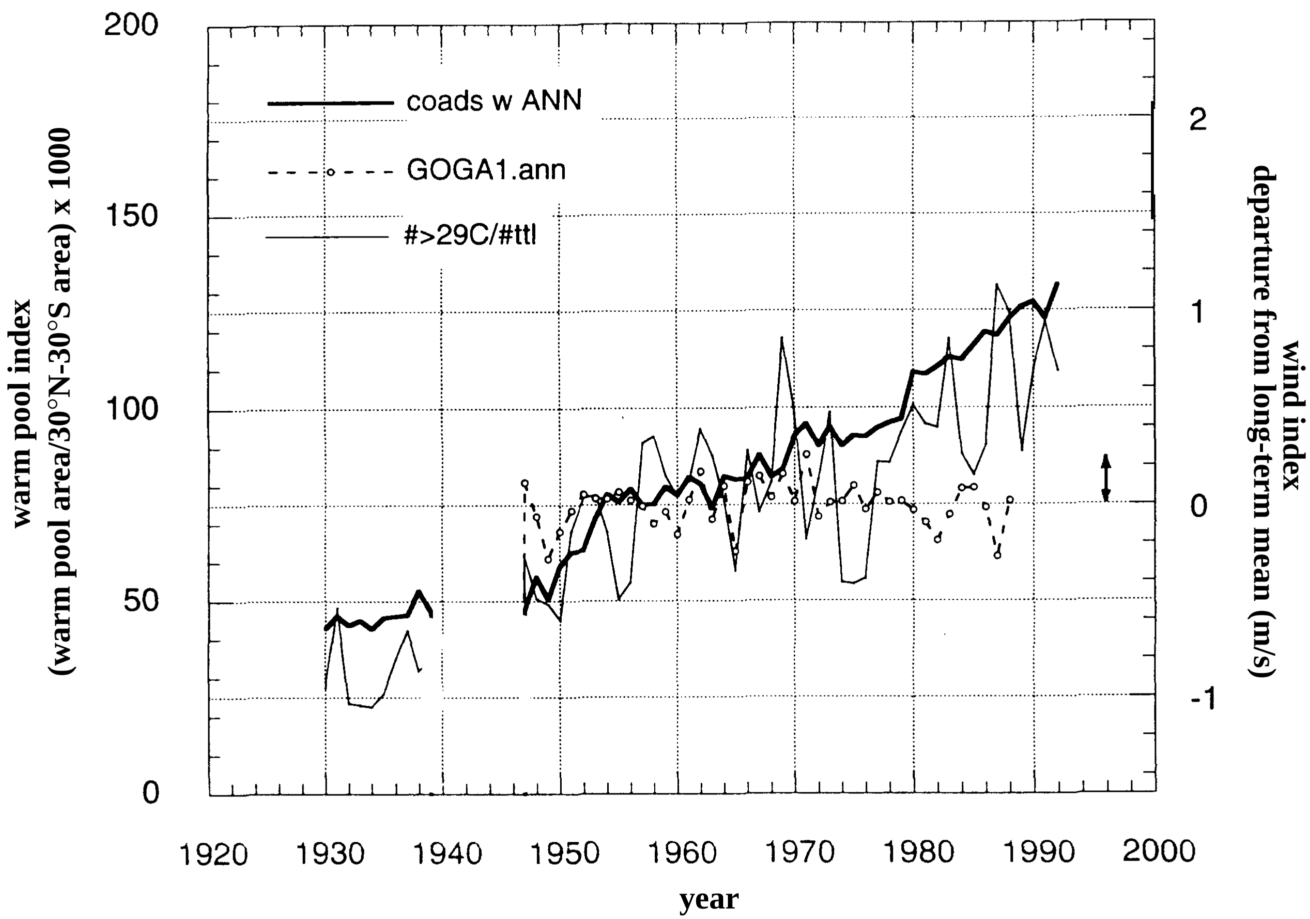


Figure 2:

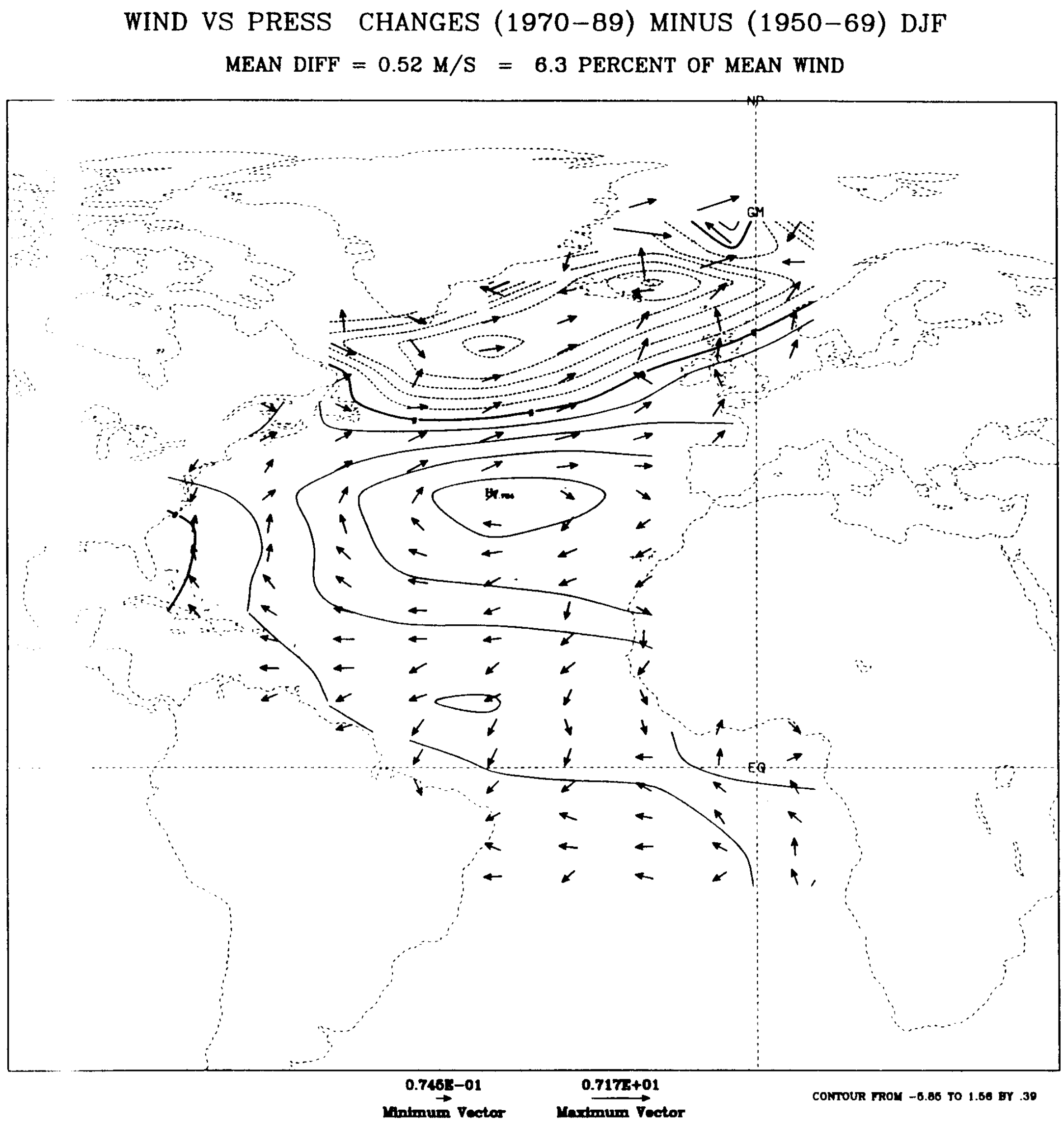
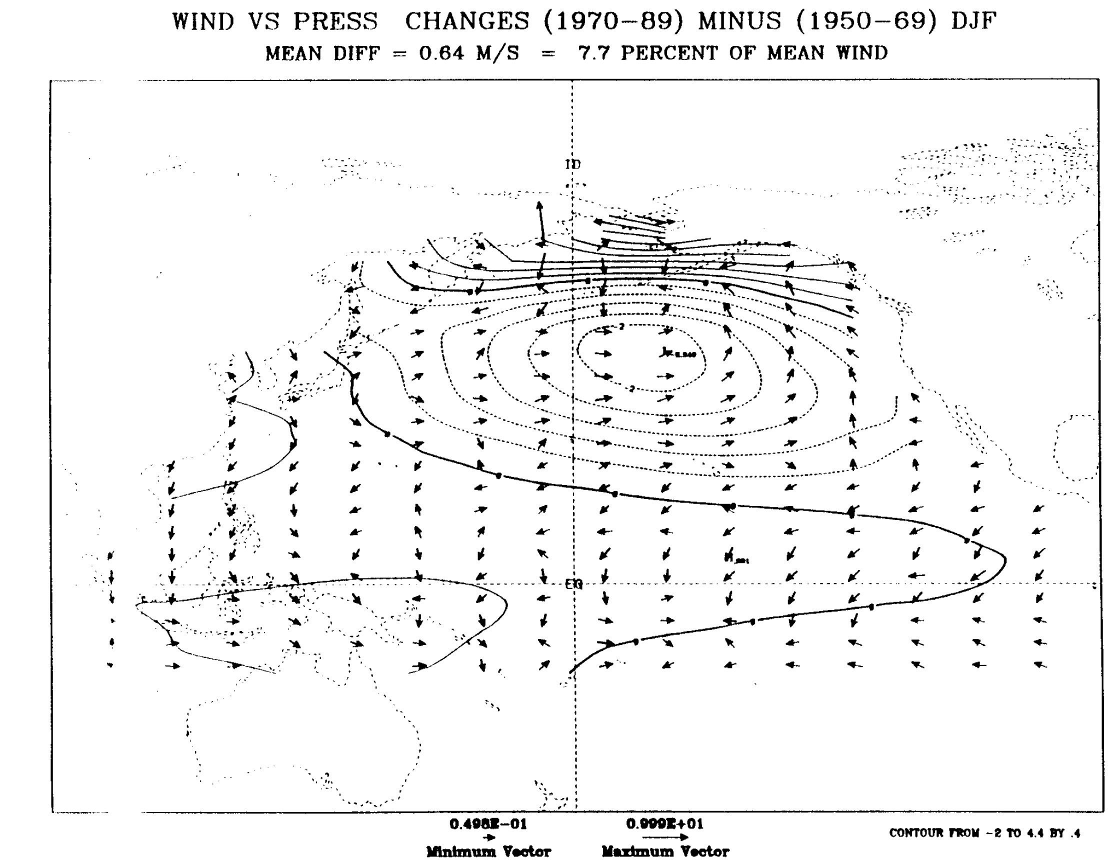
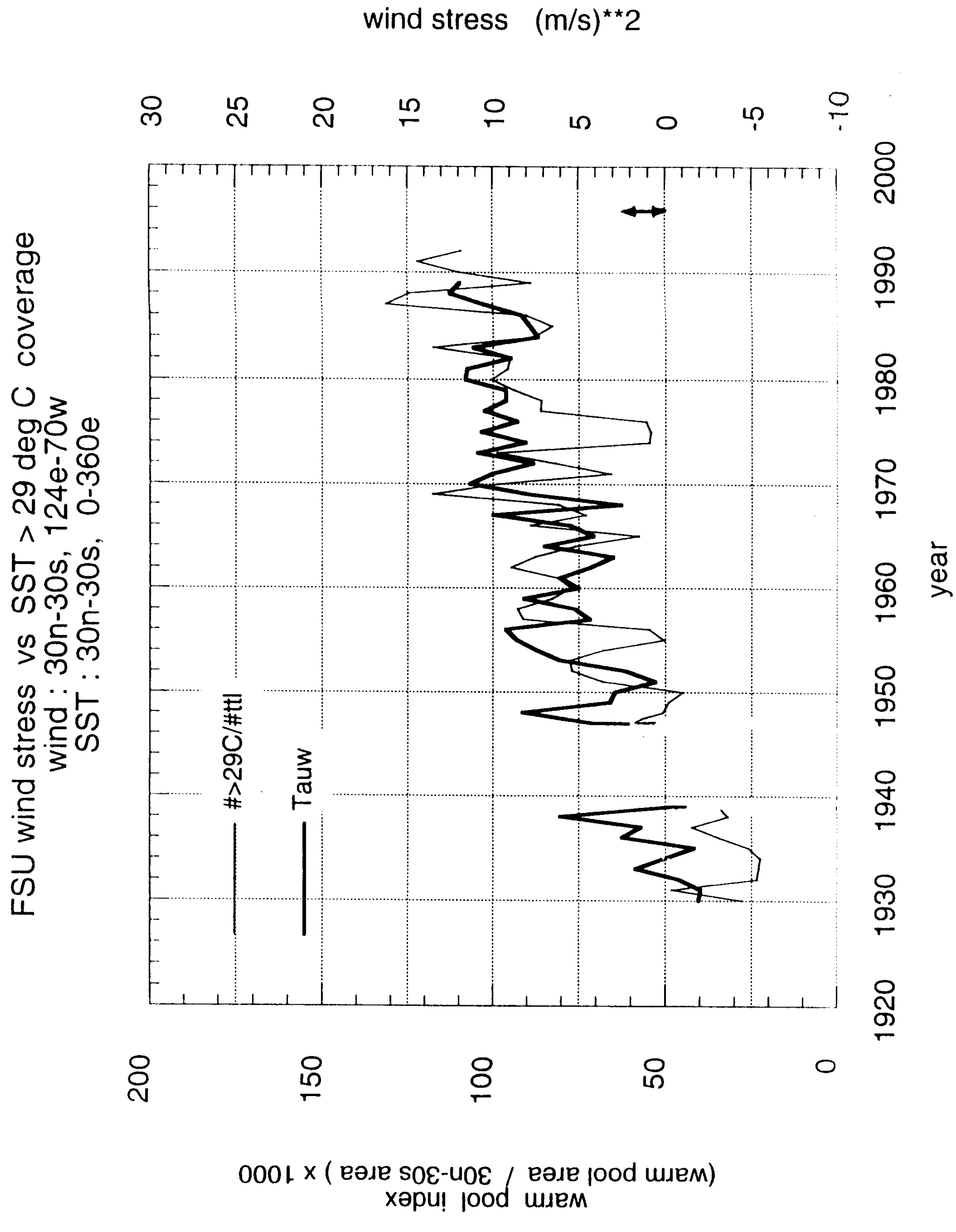

WIND VS PRESS CHANGES (1970–89) MINUS (1950–69) DJF
MEAN DIFF = 0.52 M/S = 6.3 PERCENT OF MEAN WIND
NP
GM
EQ
0.745E–01
Minimum Vector
0.717E+01
Maximum Vector
CONTOUR FROM –6.85 TO 1.56 BY .39

Figure 3:



WIND VS PRESS CHANGES (1970–89) MINUS (1950–69) DJF
MEAN DIFF = 0.64 M/S = 7.7 PERCENT OF MEAN WIND
ID
EQ
0.498E–01
Minimum Vector
0.999E+01
Maximum Vector
CONTOUR FROM -2 TO 4.4 BY .4

Figure 4:



FSU wind stress vs SST > 29 deg C coverage
wind : 30n-30s, 124e-70w
SST : 30n-30s, 0-360e
wind stress (m/s)**2
warm pool index
(warm pool area / 30n-30s area) x 1000
year
#>29C/#ttl
Tauw
1920
1930
1940
1950
1960
1970
1980
1990
2000
200
150
100
50
0
30
25
20
15
10
5
0
-5
-10