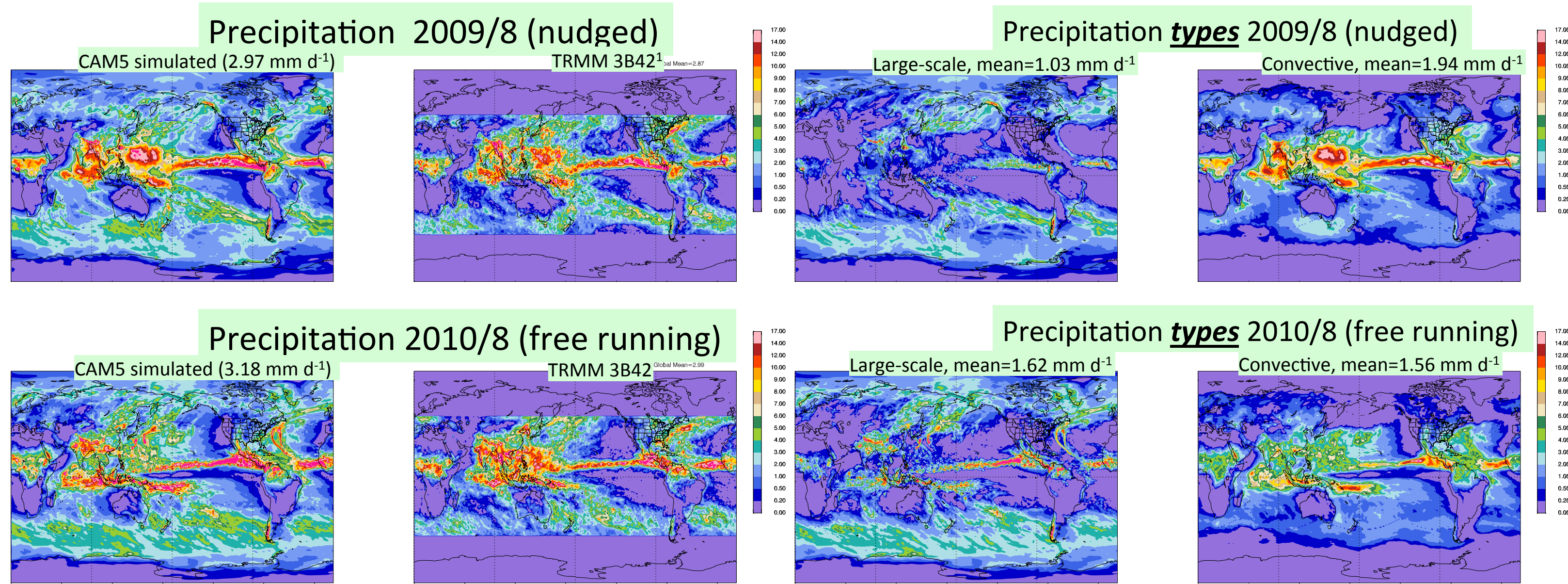


## Flexible Nudging module for CAM:

- CESM nudging is implemented via a relaxation forcing toward reanalyses values (see below).
- Data is first preprocessed onto the model native grid for the desired dynamical core e.g. SE, FV, EUL. via NCL scripts. (*courtesy Jerry Olson AMP*)
- Data for YOTC (2 years @ ne120,ne30) and ERA-I (34 years @ ne30) have been processed for use.
- The strength and 3D structure of U, V, T, and Q nudging can be independently specified via namelist parameters.
- The localized 3D structure of the nudging is specified via *tanh* window functions.



**Fig.1)** Monthly mean precipitation fields for ne120 (25km) CAM and TRMM 3B42. Top row shows results for Aug 2009 obtained with full nudging. Bottom row shows results for Aug 2010 from a free-running simulation.

**Fig. 2)** Precipitation types for experiments shown in Figure 1. Note increased proportion of convective rain in nudged run (top).

- Nudging can keep physics variables, e.g., precipitation (Fig.1), close to observations
  - Pattern correlations of daily precip with TRMM range from 0.4 to 0.7 depending on variables nudged
- **Caution: Nudging runs may not preserve some important characteristics of parent model, e.g., convective/large-scale rain ratios (Fig. 2).**
  - This could be a problem for some applications
  - **Hypothesis:** Nudging interferes with divergent flow

## Nudging Tendencies:

$$\dot{\chi}_{ndg} = \frac{\chi_m(t_m) - \chi_{ana}(t_{ana})}{\tau_{ndg}} \quad (1)$$

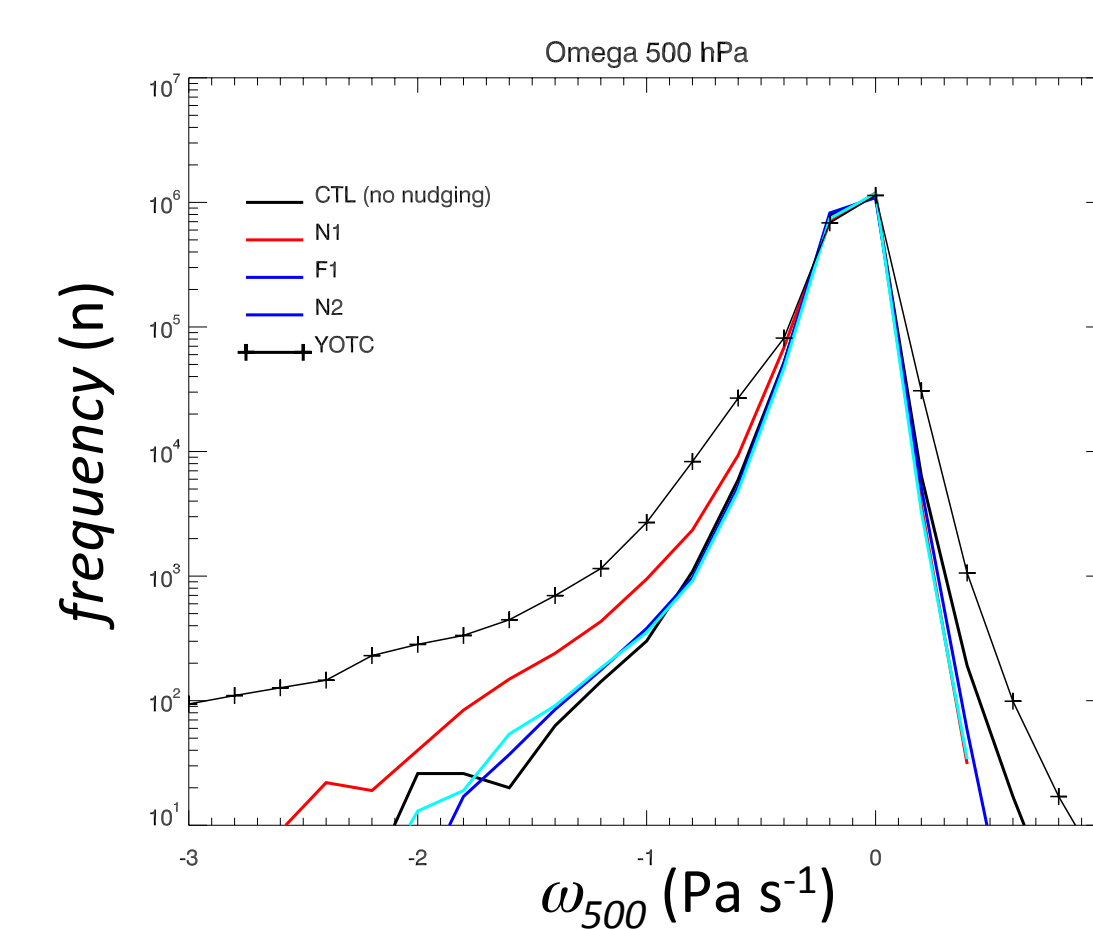
$t_m$  = model update times,  $t_{ana}$  = analysis times,  
 $\tau_{ndg}$  = nudging time scale,  $\chi=u,v,T$ , or  $q$

- Typical implementations update model field every physics time step\*, i.e.,  $t_m$  is simply “time”. Nudging timescale is typically 6 hours.
- Nudging keeps flow close to analysis but tendencies could exert strong damping on integrations
- Infrequent  $t_m$  updates lead to instabilities
- What to do? Explore sensitivities (*ne30!!*)

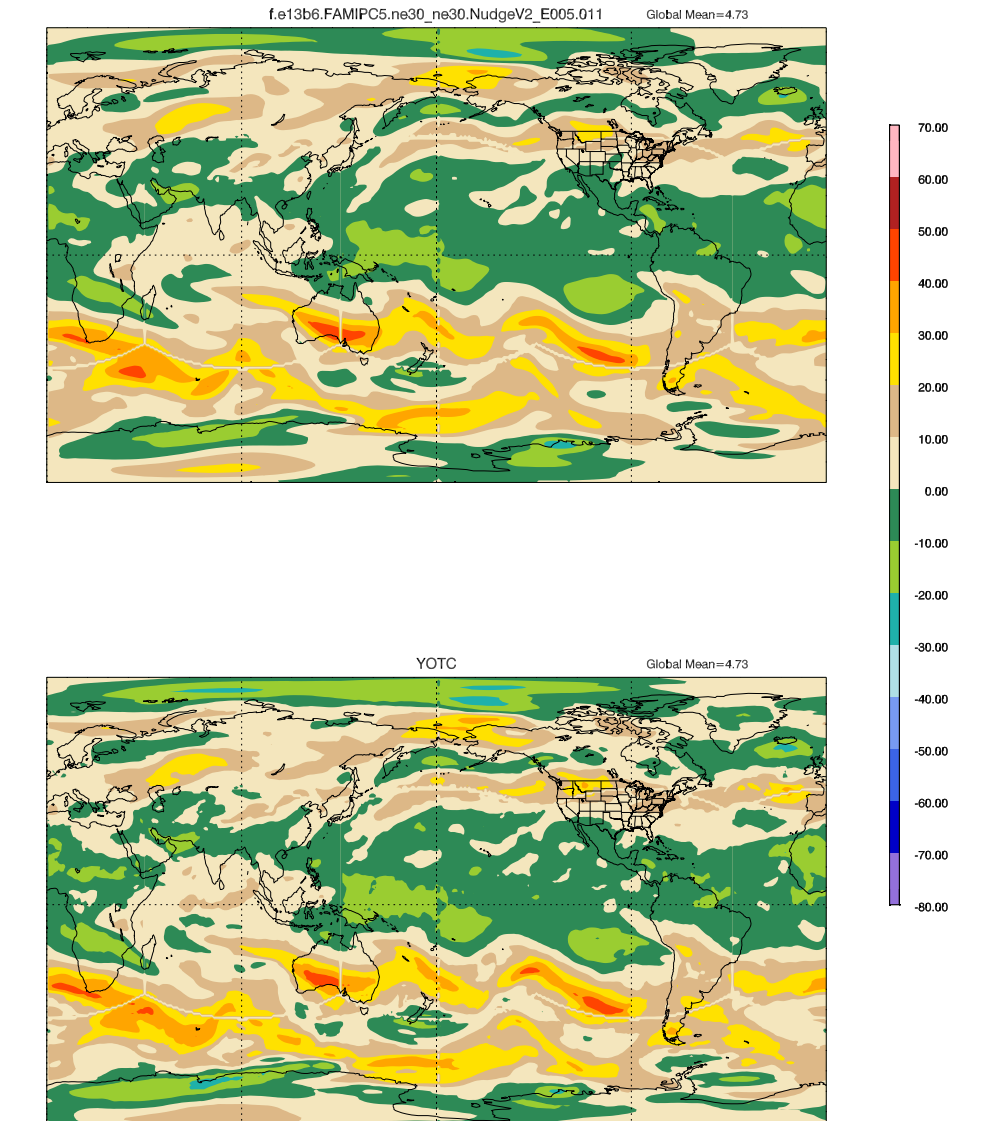
Experiment	$t_m$ updates per day	$\tau_{ndg}$
CTL	--	--
N1	48	6
F1	4	18
N2	48	18

Table 1. Parameter values in nudging term (Eq. 1). varied to test effects on divergent flow

\*with  $t_m$  updated every 6 hours, i.e., at analysis intervals this becomes forward-in-time analog of incremental analysis update (IAU, Bloom et al.,1996 *MWR*) used in MERRA reanalysis project.



**Fig.3)** Frequency distributions of instantaneous vertical motion accumulated every 6 hours over one month for experiments listed in Table 1 and for YOTC reanalyses interpolated to the SE ne30 grid. Note strong ascent in N1 (Table 1, 2<sup>nd</sup> row).



**Fig.4)** Instantaneous zonal wind at 500 hPa: top) from run F1; bottom) from YOTC re-analysis ( $r>0.96$ ).

**Conclusion:** Nudging impact on divergent flows can be controlled while maintaining large scale flow close to analysis (only ne30 examined so far)