

# Surface Pressure Tides in WACCM and other Climate Models

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# Motivation

- Regular pressure tides near the surface provide a test bed for evaluating model physics related to diurnal heating within the atmosphere and at the surface.
- Surface pressure tides in GCMs have been analyzed for a few models, but not for WACCM and most IPCC AR4 models.
- The inter-comparison between WACCM and regular GCMs provides an assessment of the effect of upper atmosphere (>30km) on surface pressure tides.

# The Role of Upper Atmosphere



- Classical tidal theory predicts that ozone heating explains  $\sim 2/3$  of the  $P_2$  semidiurnal tide ( $S_2$ );
- Since most GCMs have a top at 30-40km, below the peak ozone heating ( $\sim 50$ km), one might expect these models to have a weak  $S_2$ ;
- However, this analysis and earlier analyses show that this is not the case!
- Then what are the possible explanations?

# Model and Obs. Data



- 3-hourly surface pressure ( $P_s$ ) from WACCM-1 and WACCM-3 for Jan. 1991
- 3-hourly sea level pressure (SLP) from IPCC AR4 models
- 3-hourly  $P_s$  from ship and station obs. (1976-1997) (Dai and Wang'99)

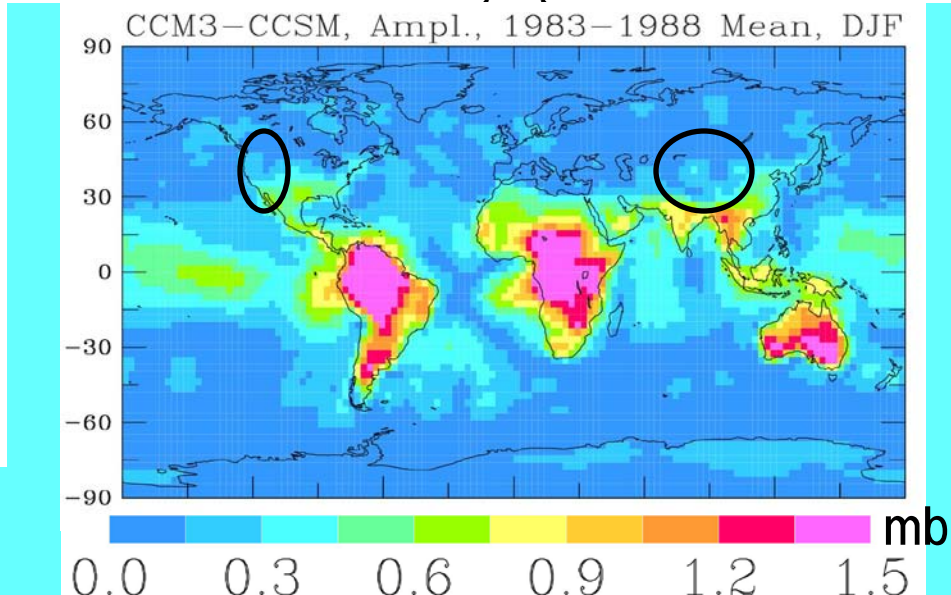
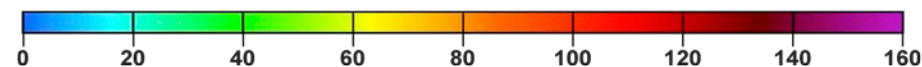
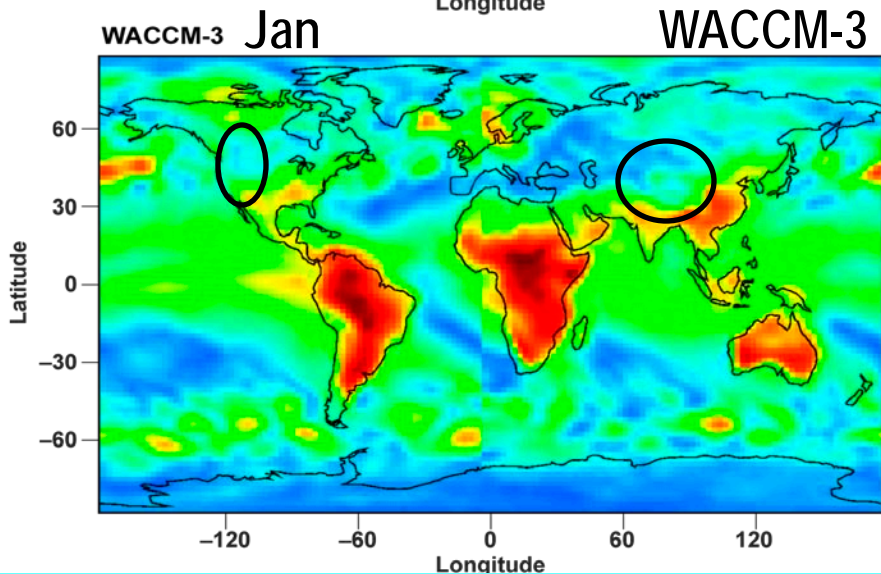
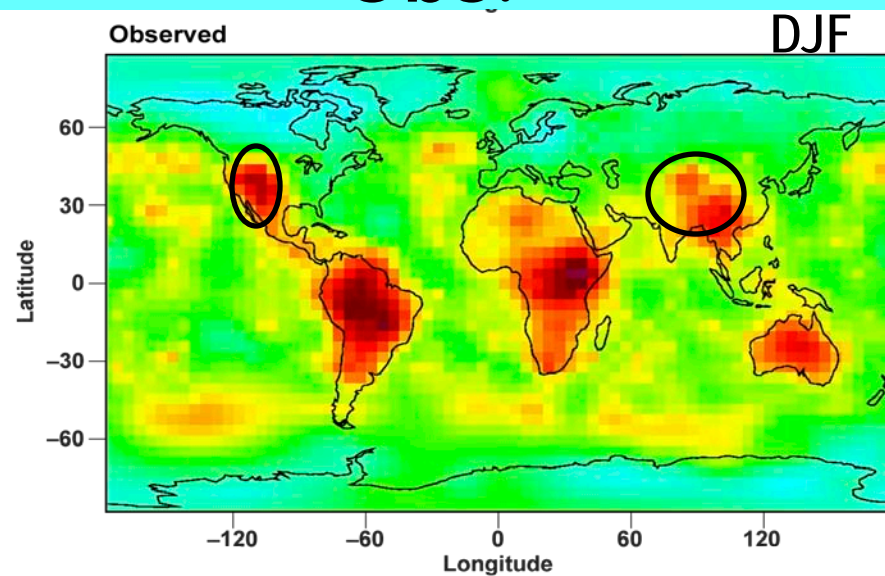
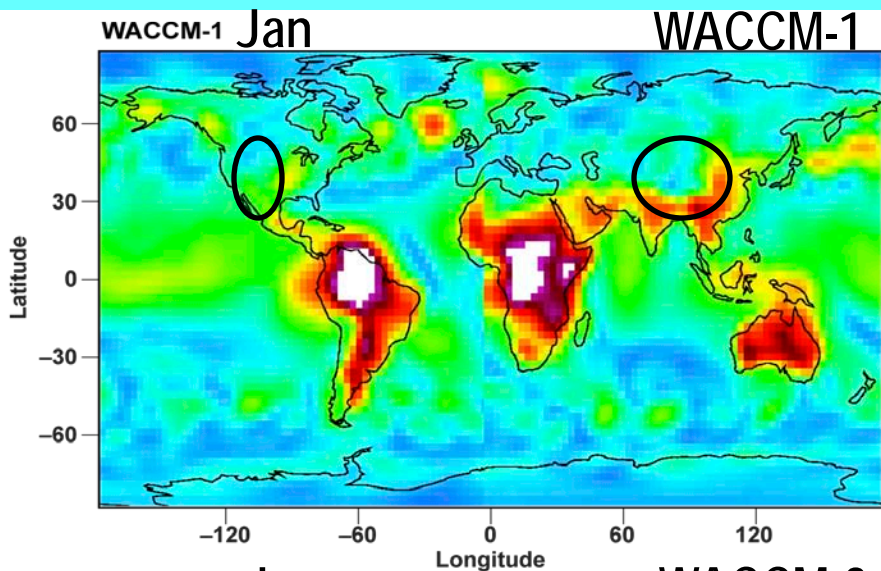
**TABLE 1: Tides Near “Batavia” (now Jakarta): 14°S–2°N, 97.5°E–112.5°E**


Source			Diurnal component		Semidiurnal component	
	Model Top	Str.Levs	Ampl. [mbar]	Tmax [LST]	Ampl. [mbar]	Tmax [LST]
CNRM-CM3	0.05 mb	20	0.7165	4:35	1.4010	9:35
CNRM-CM3 AMIP			0.7601	4:42	1.3762	9:38
GFDL-CM2.0	3.00 mb	4	0.4402	6:16	1.3455	10:22
GFDL-CM2.1	3.00 mb	4	0.6095	5:46	1.3112	10:39
GISS-EH	0.10 mb	10	0.7039	4:15	1.7625	10:35
GISS-ER	0.10 mb	10	0.9469	4:19	1.8195	10:33
GISS-ER AMIP			0.7762	4:54	1.7533	10:09
INM-CM3.0	10.00 mb	7	0.6513	5:08	1.4486	10:04
INM-CM3.0 AMIP			0.7378	3:47	1.4763	10:03
MIROC3.2(hi-res)	40 km ≈ 3 mb	22	0.4043	6:16	1.4801	10:09
MIROC3.2(hi-res) AMIP			0.5774	6:31	1.4452	10:11
MIROC3.2(med-res)	30 km ≈ 10 mb	6	0.6403	6:60	1.7809	10:54
MIROC3.2(med-res)AMIP			0.6238	7:34	1.6323	10:52
MRI-CGCM3.2	0.40 mb	7	0.5923	5:46	1.9330	11:14
MRI-CGCM3.2 AMIP			0.4899	5:38	1.7558	10:57
WACCM-1 Jan climat PS	3×10 <sup>-6</sup> mb	51	0.5205	5:17	1.2520	10:48
WACCM-1 Jan climat PSL			0.5491	5:12	1.2599	10:48
WACCM-1 Jul climat PS			0.5709	3:15	1.1361	10:48
WACCM-1 Jul climat PSL			0.5945	3:17	1.1428	10:47
WACCM-3 Jan climat PS	3×10 <sup>-6</sup> mb	51	0.5474	4:34	1.3474	9:53
<b>OBSERVATIONS</b>			<b>0.6491</b>	<b>5:59</b>	<b>0.9984</b>	<b>9:56</b>

# Amplitude of Diurnal Tide S1



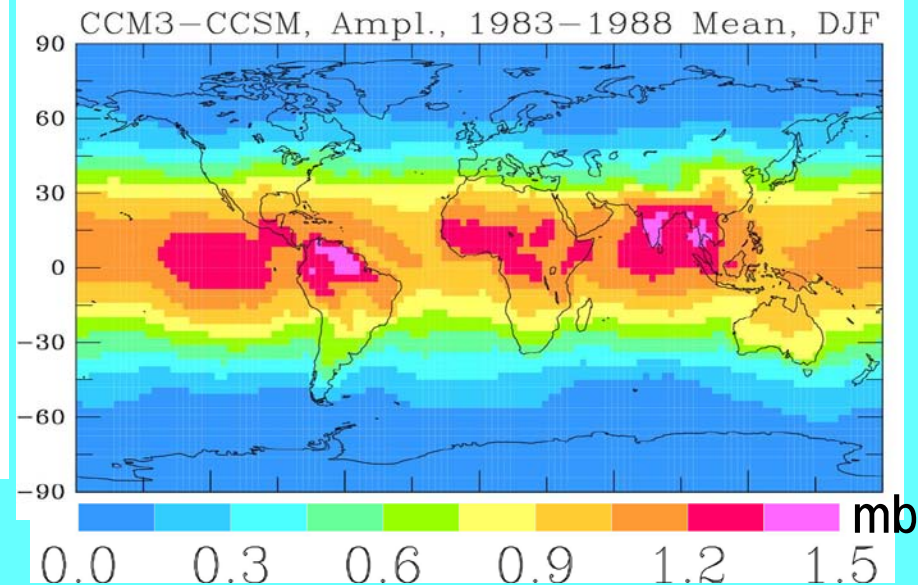
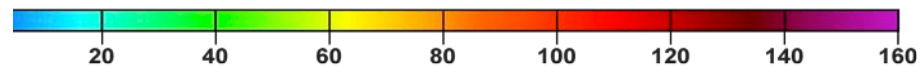
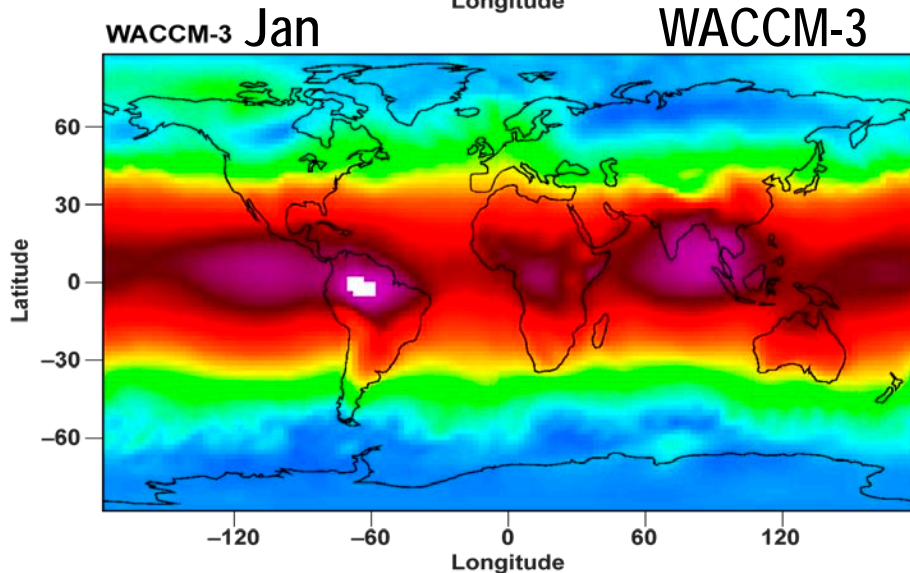
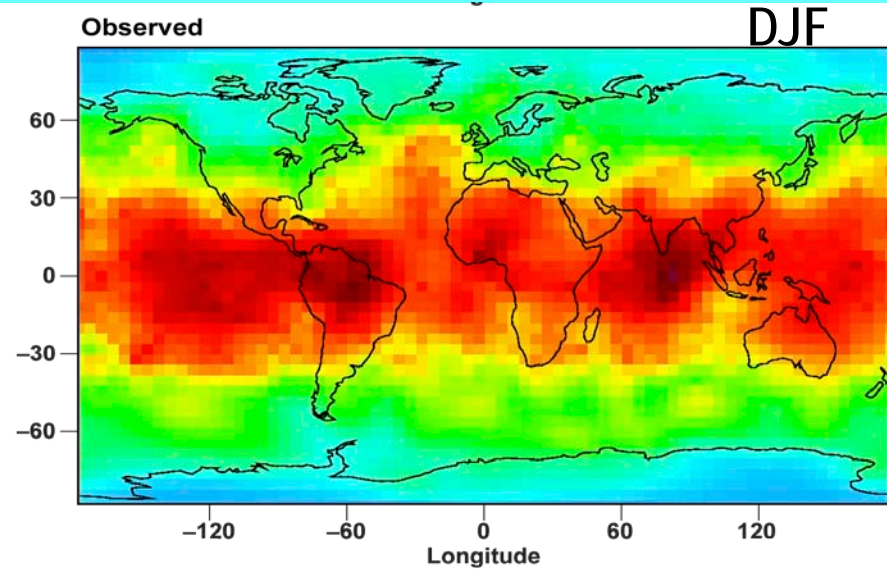
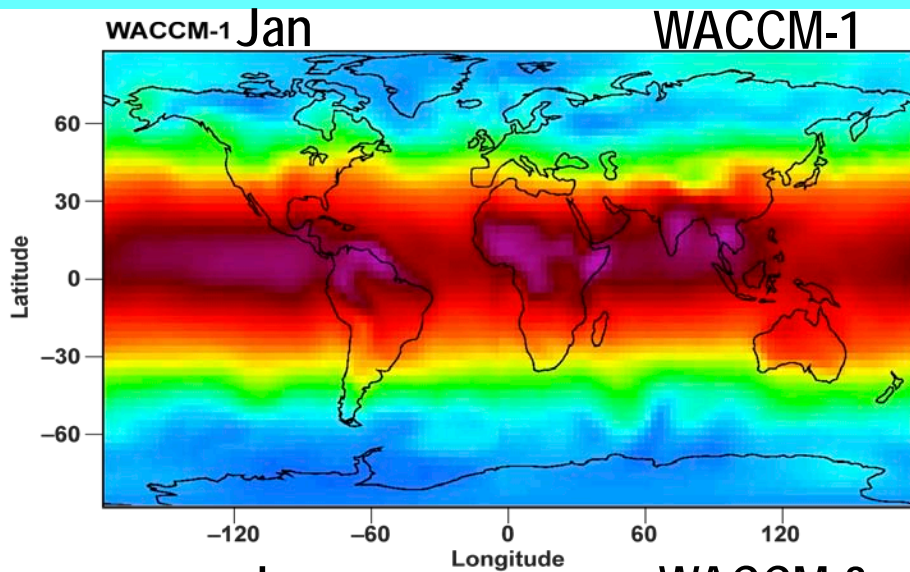
Obs.



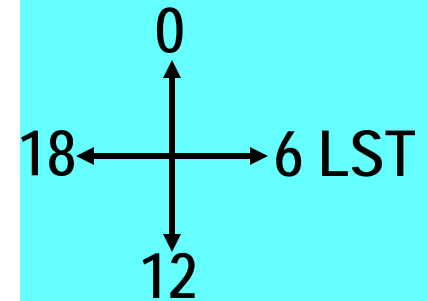
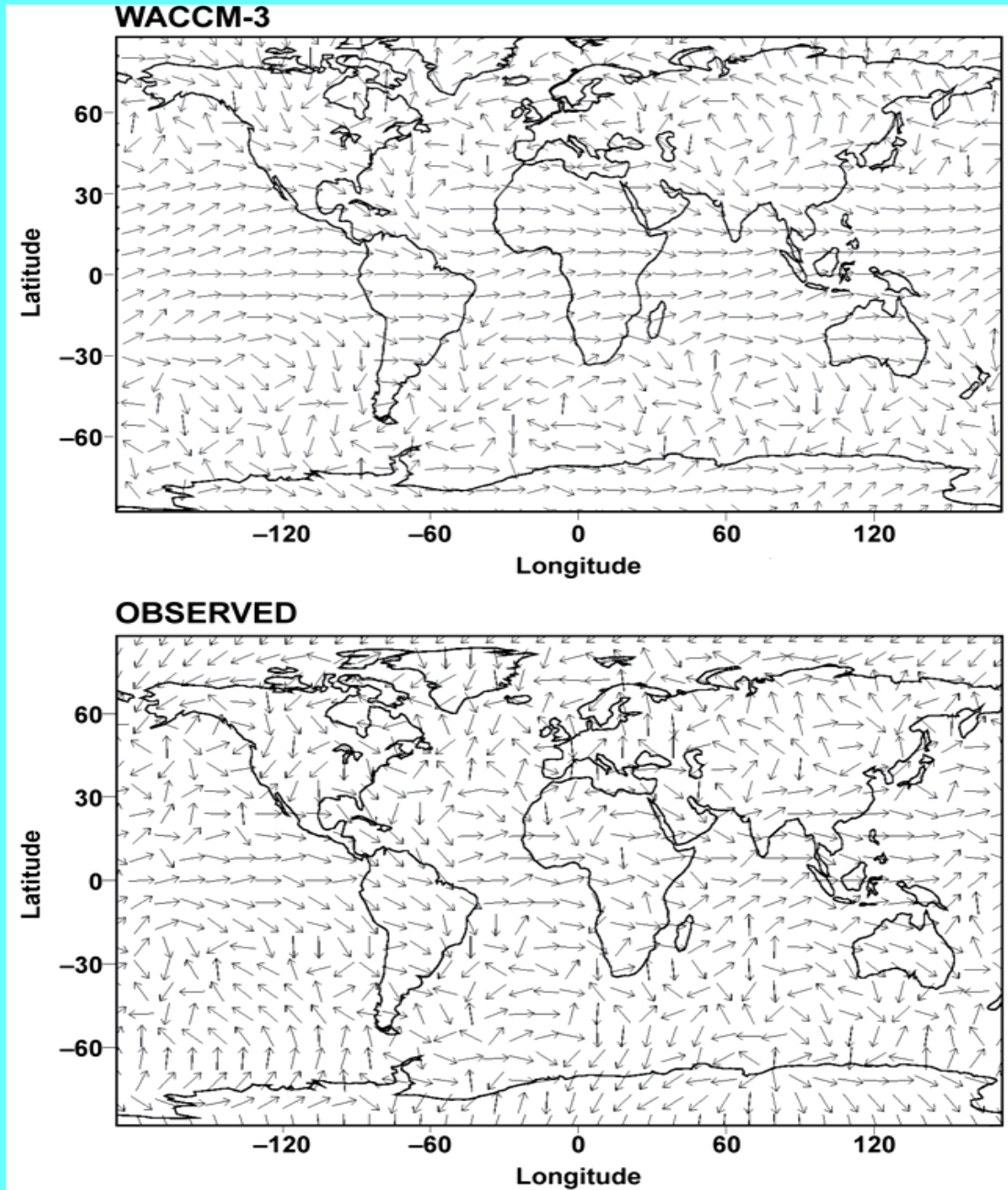
# Amplitude of Semi-diurnal Tide S<sub>2</sub>



Obs.

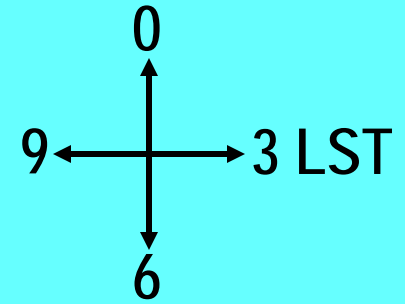
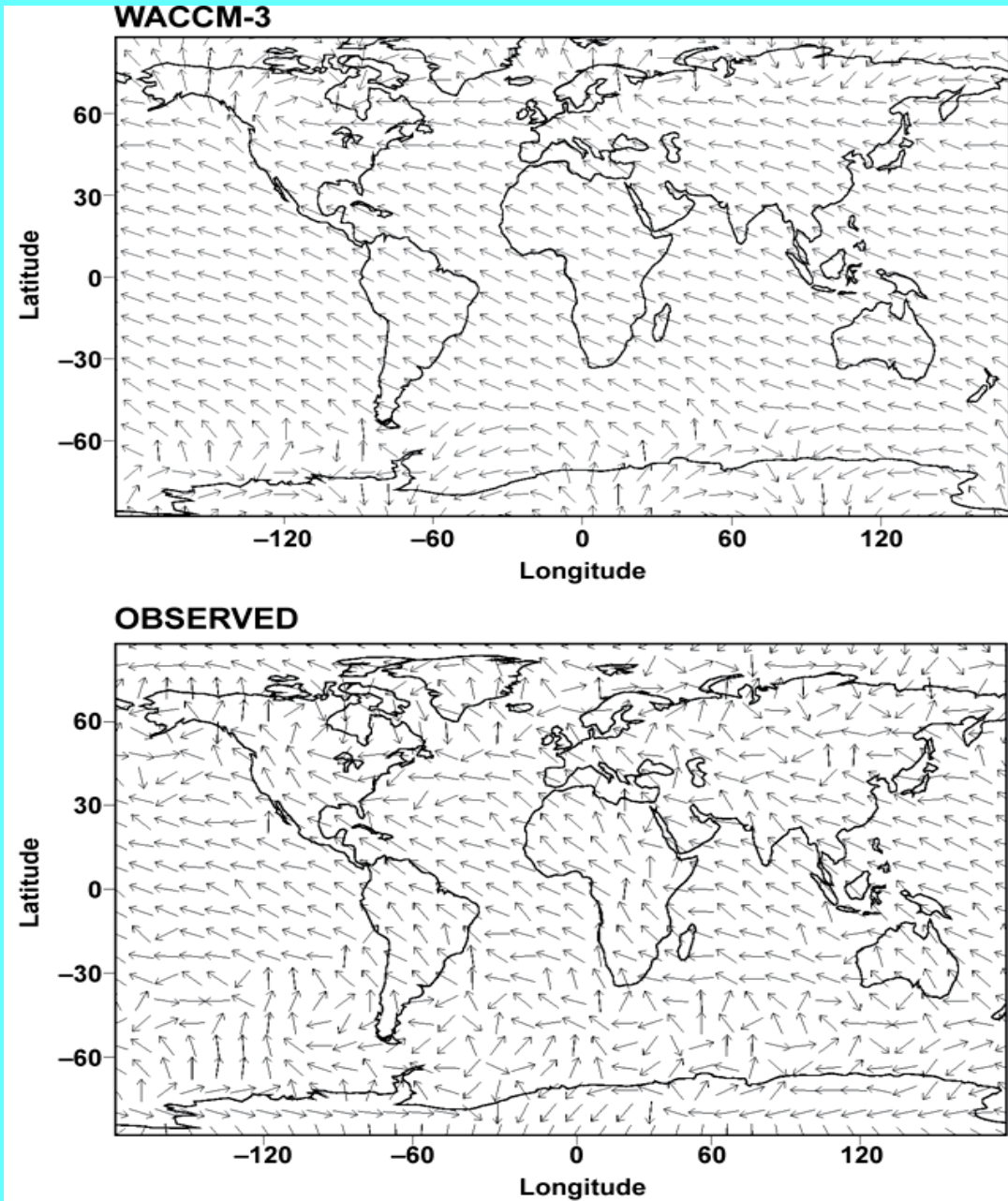


# Time of Maximum of Diurnal Tide S1

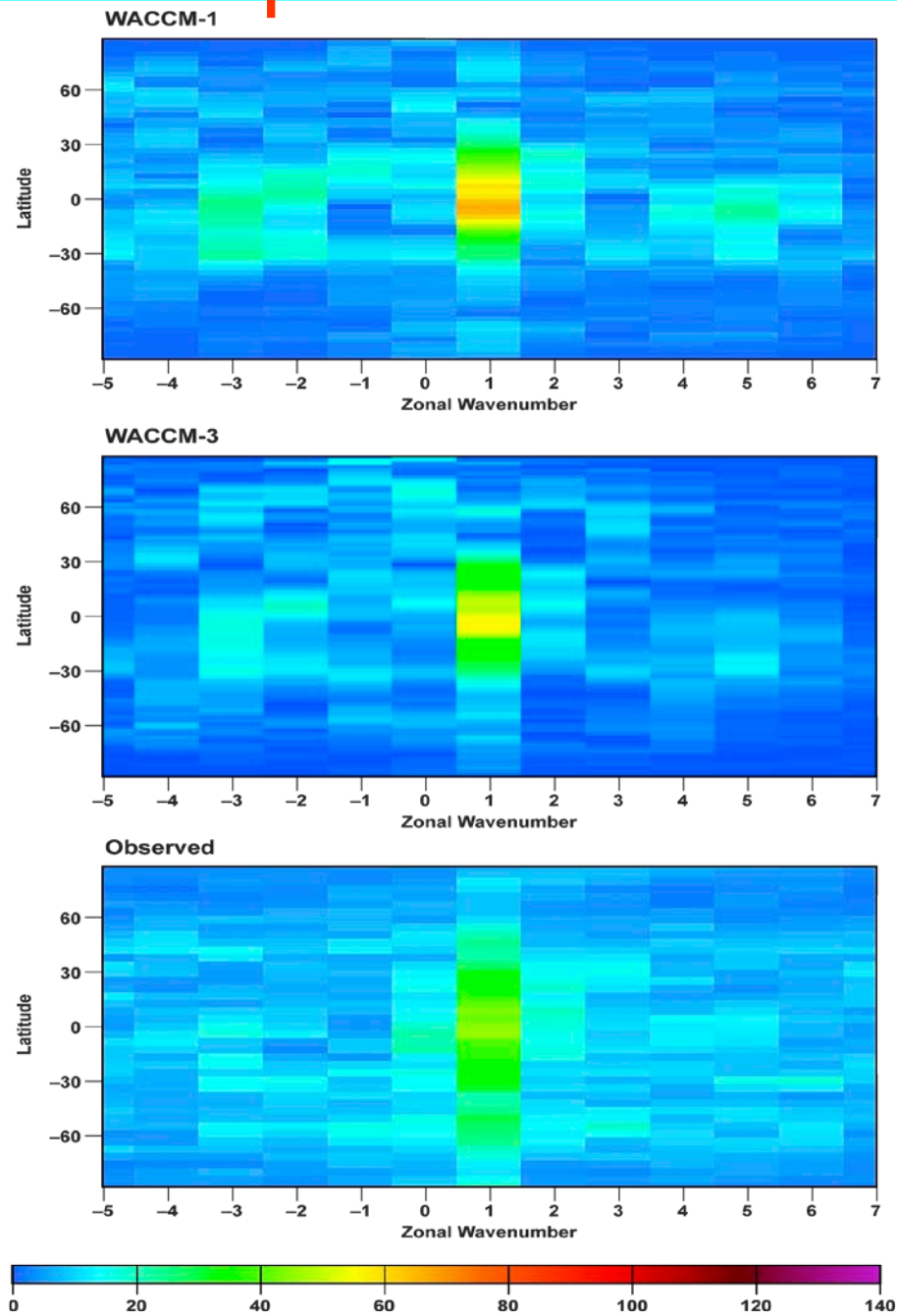




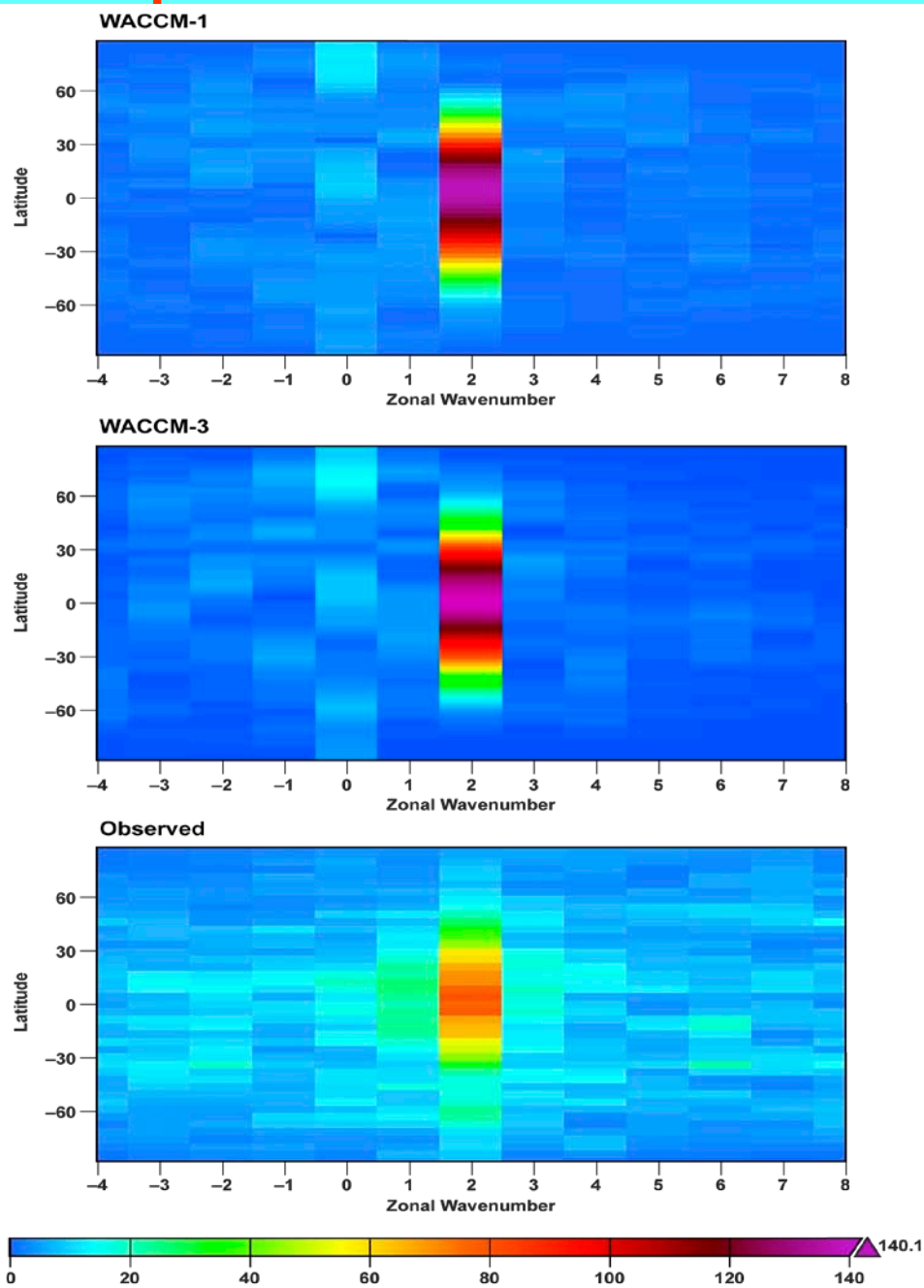
# Time of Maximum of Semi-diurnal Tide S2



# Zonal Wave Components of Diurnal Tide S1



# Zonal Wave Components of Semi-diurnal Tide S2



# Summary



- *WACCM*-1 and -3 produce similar *S1* and *S2* that are comparable to obs., with the migrating component being too strong, especially for *S2*.
- The similar *CAM2* (with a top at ~40km) produces *S1* and *S2* only slightly weaker than *WACCM*.
- Both *WACCM* and *CAM2* failed to produce the large *S1* observed over the Rockies and Tibetan Plateau.
- Other *GCMs* with tops below 40km also produced *S1* and *S2* broadly comparable to obs.