Simulations of the neutral dynamics during the 2009 SSW in different whole atmosphere models

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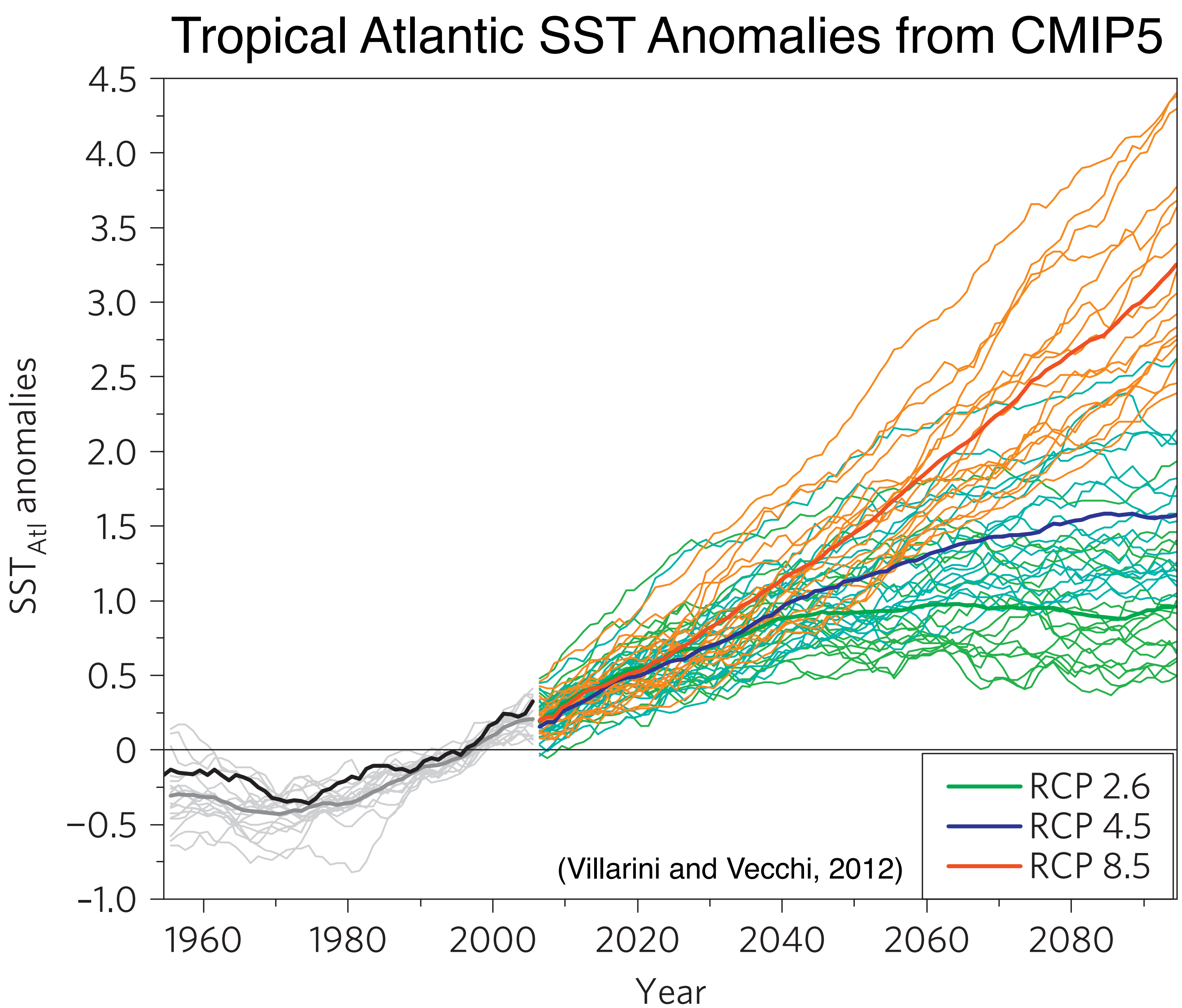
Under identical forcing conditions, significant differences exist in model results due to uncertainties in parameterizations, numerical methods, etc.



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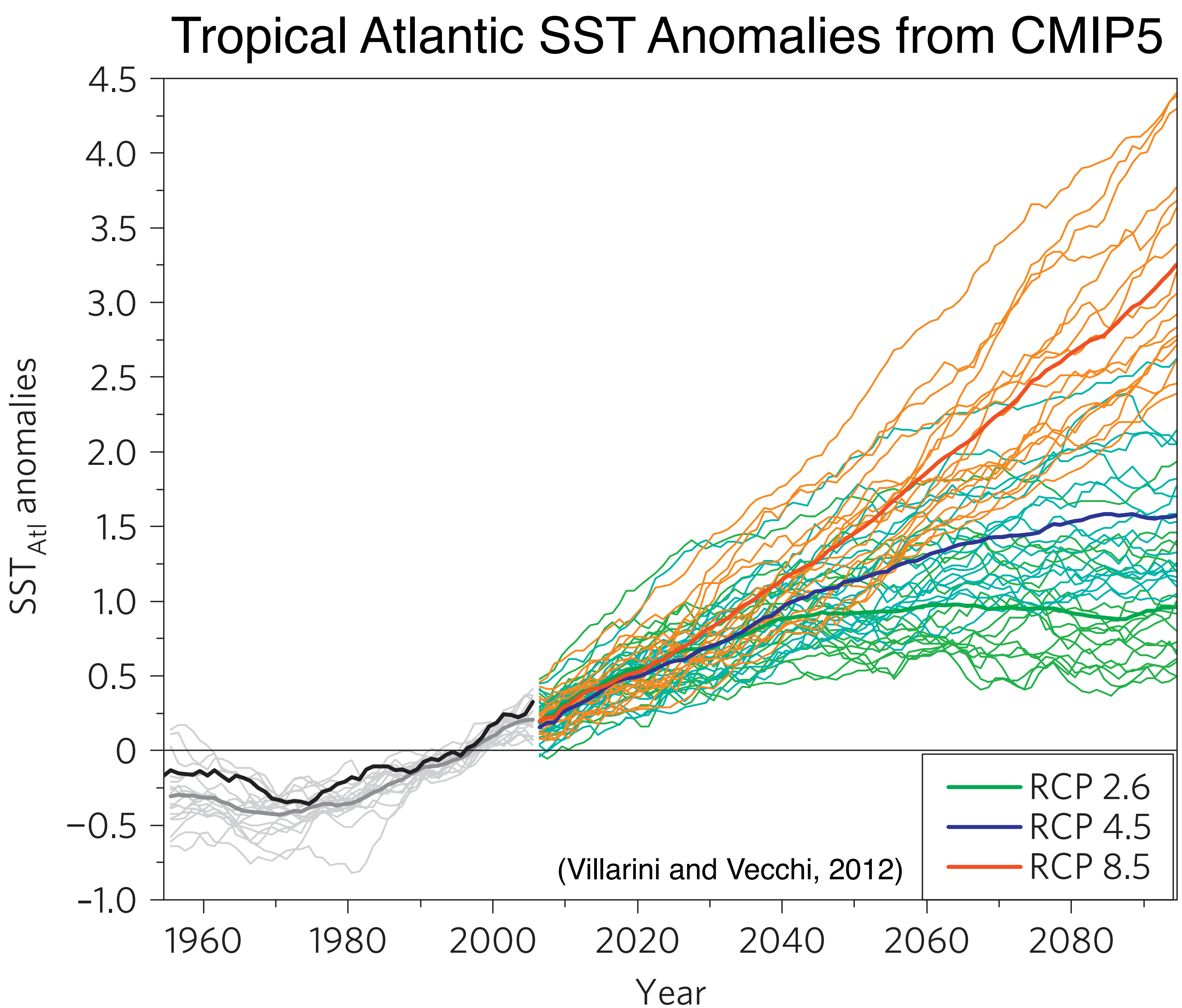
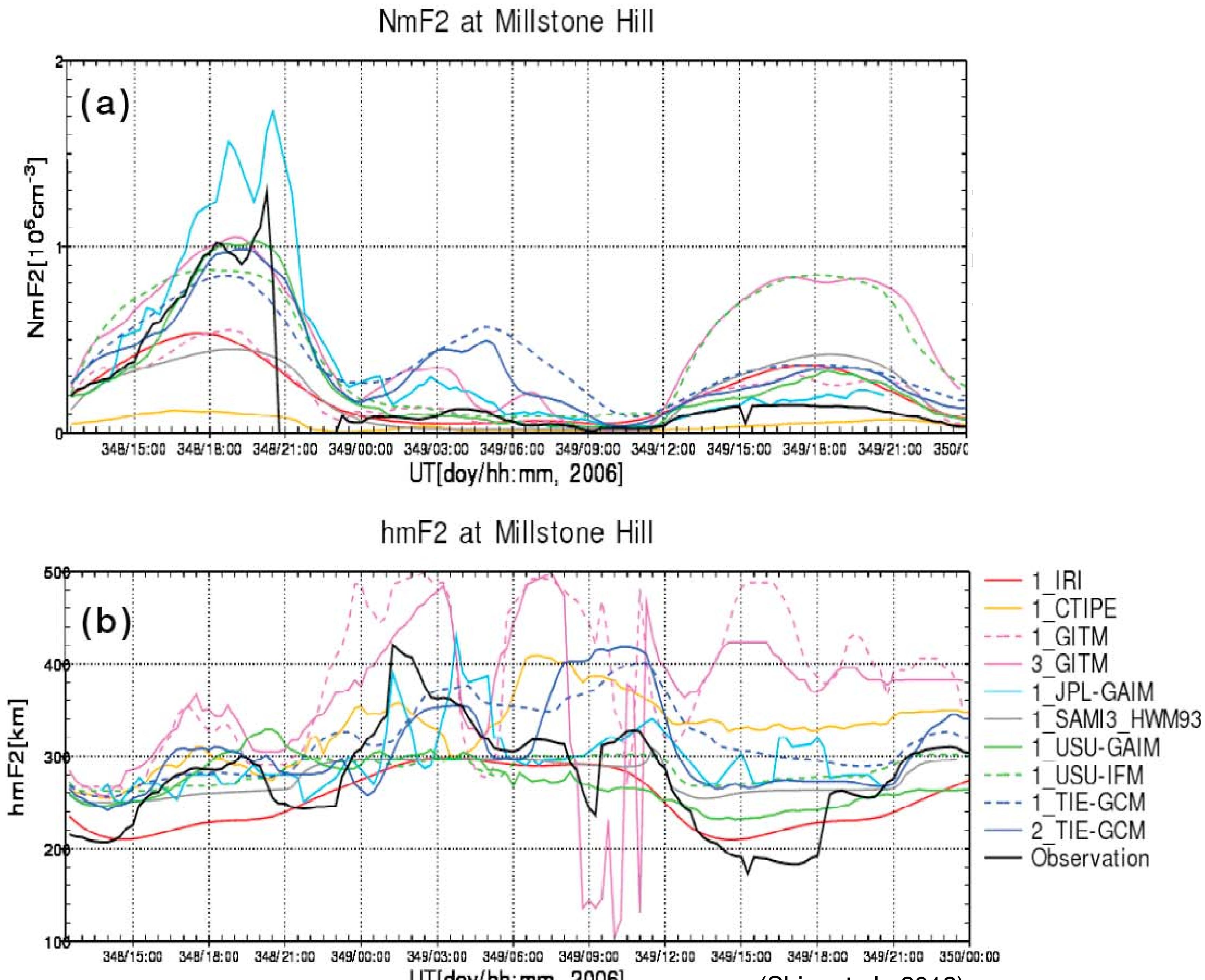


Comparison of different model results is necessary to understand the potential uncertainty in model simulations

Large deviations are also present in comparisons of upper atmosphere models



(Shim et al., 2012)

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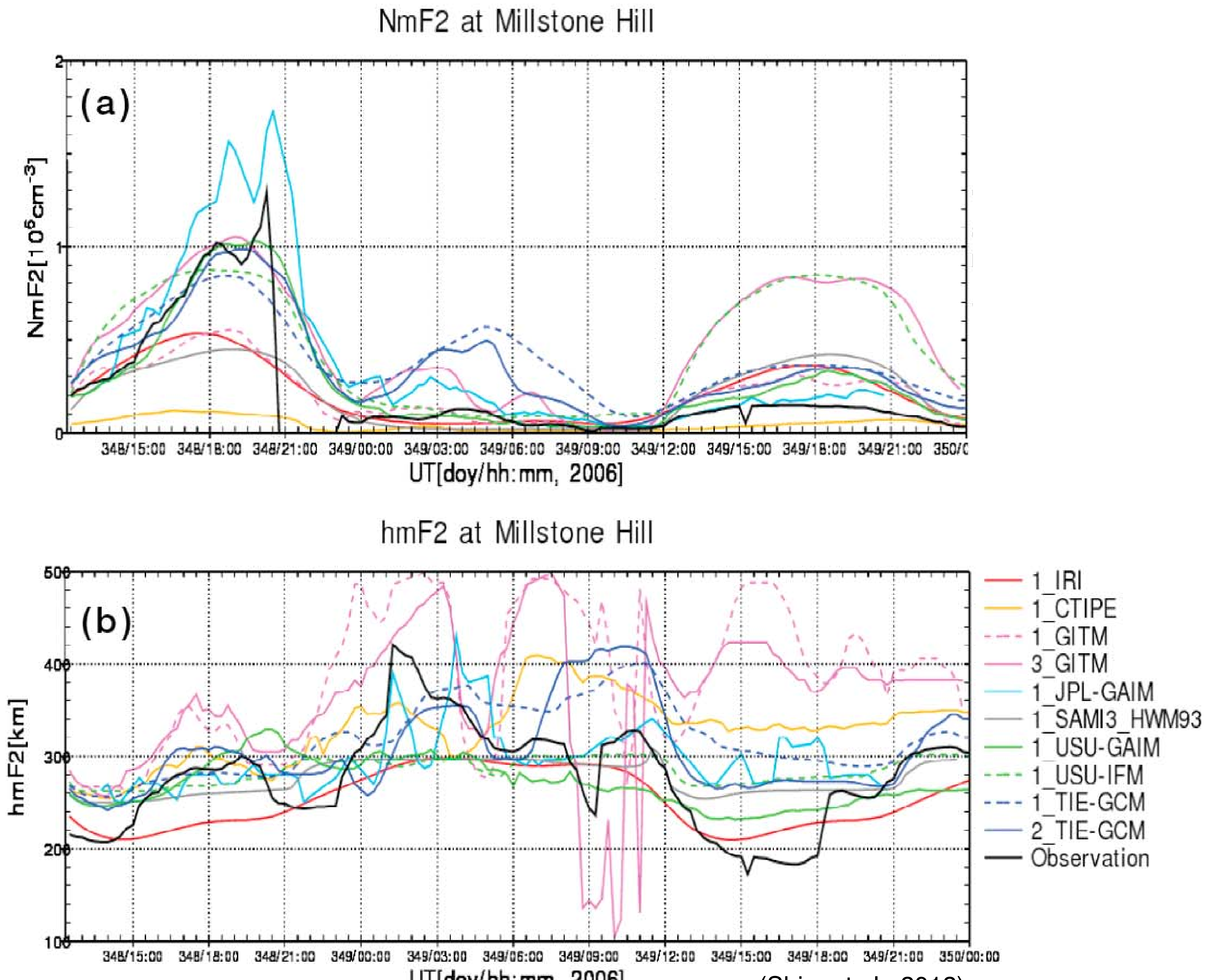


(Shim et al., 2012)

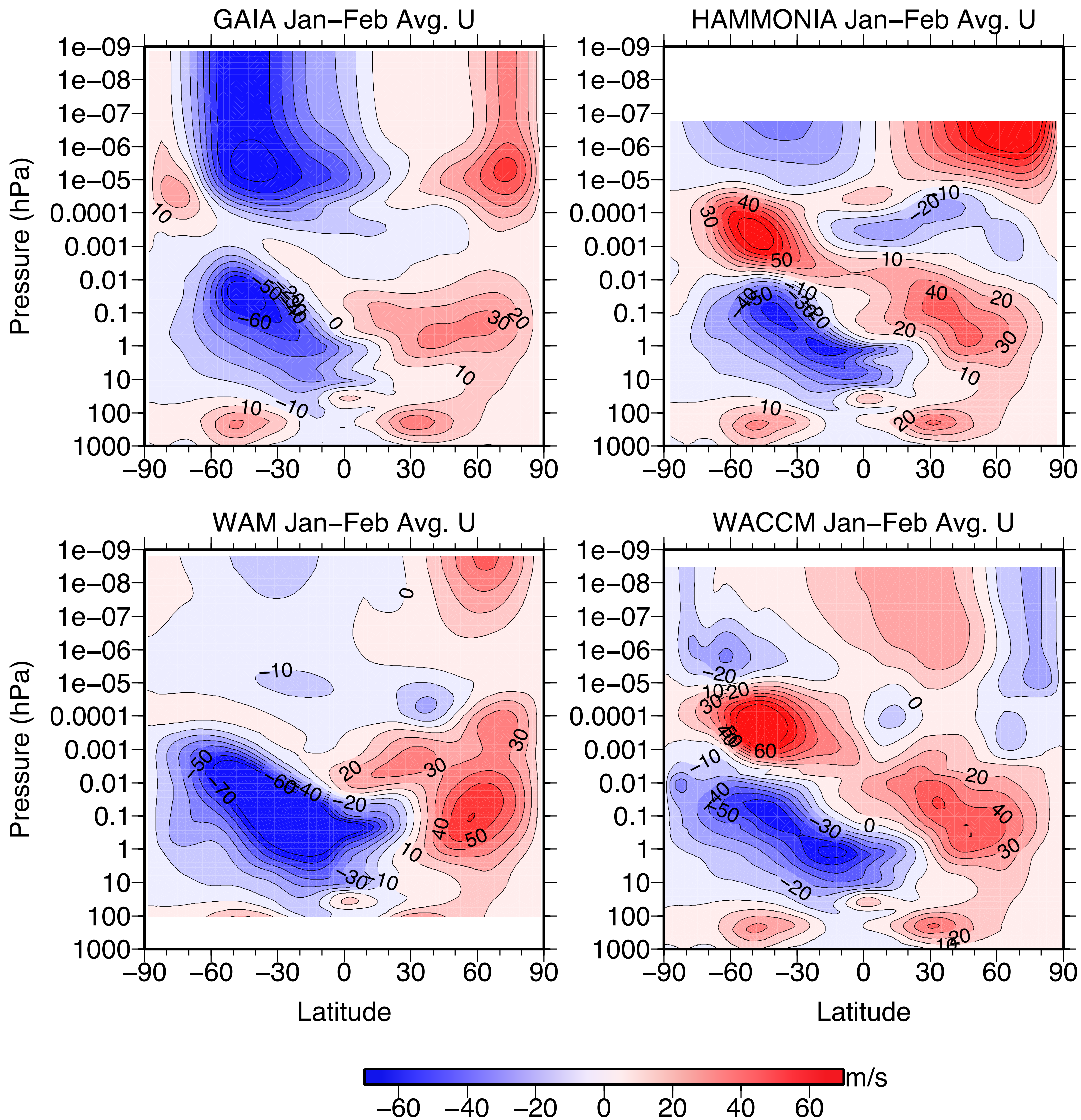
The present study compares whole atmosphere model results for the 2009 SSW in order to illustrate common features, and potential uncertainties, in the dynamical variability that occurs in response to the SSW.

Whole Atmosphere Models Simulations

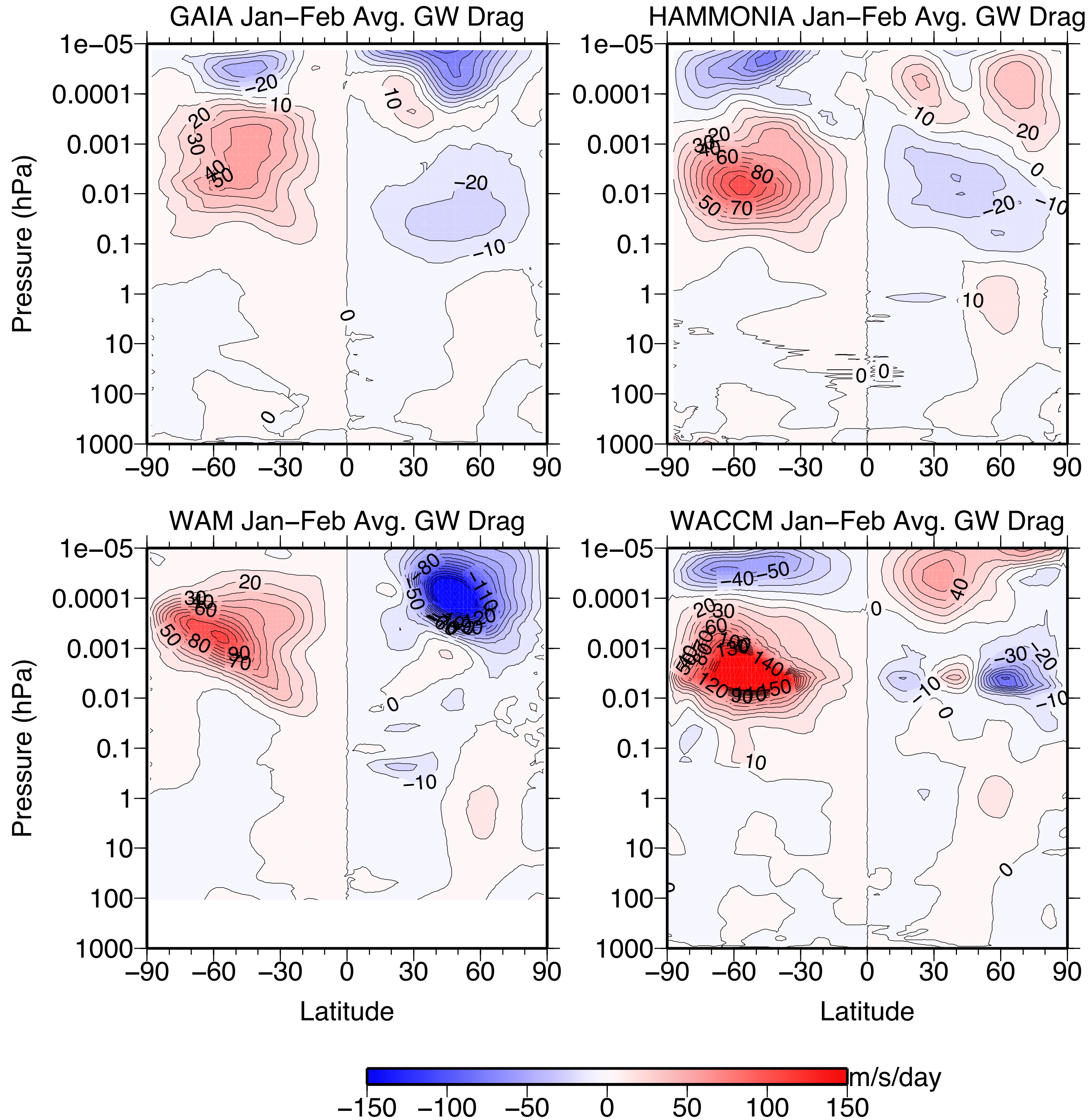
Model	Constraint	Coupled Ionosphere	Ozone	Gravity Wave
GAIA	Nudging, JRA-25 up to 30 km	Yes	No (Climatology)	Lindzen (1981)
HAMMONIA	Nudging, ECMWF up to 180 hPa	No	Yes	Hines (1997)
WACCM-X	Nudging, NOGAPS-ALPHA/ MERRA up to 90 km	No	Yes	Lindzen (1981)
WAM	NCEP GSI Data Assimilation	No	Yes	Hines (1997)

All models provided hourly output for comparison of the neutral dynamics during the 2009 SSW. Model output was processed identically for each model.

Models exhibit different climatology, and this will impact the variability due to the SSW



The different gravity wave parameterizations are primarily responsible for the zonal mean zonal wind differences



$$\bar{F}_x^{GW} = -\left(f + \frac{\bar{u}\tan\phi}{r}\right)\bar{v}$$

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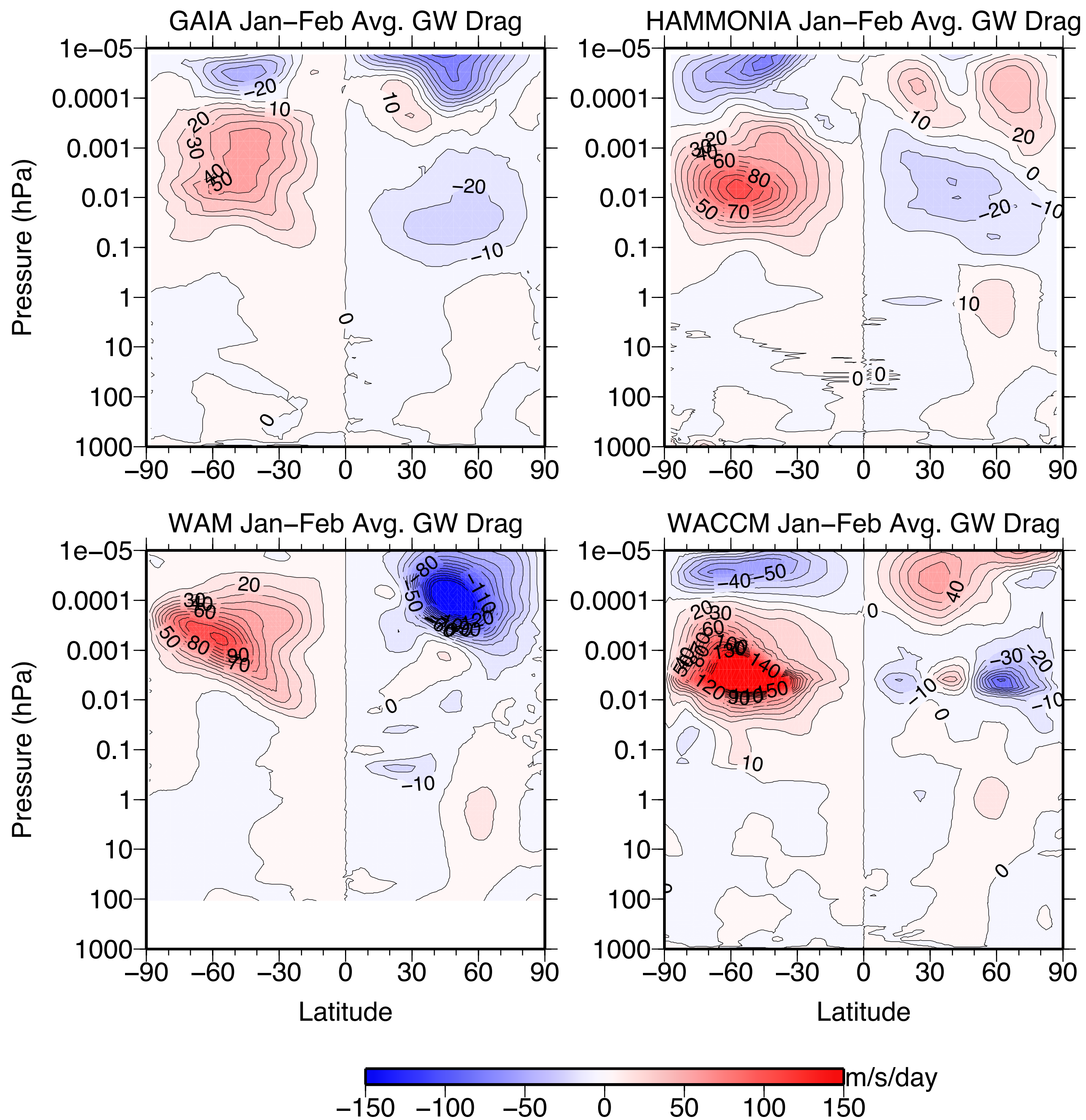
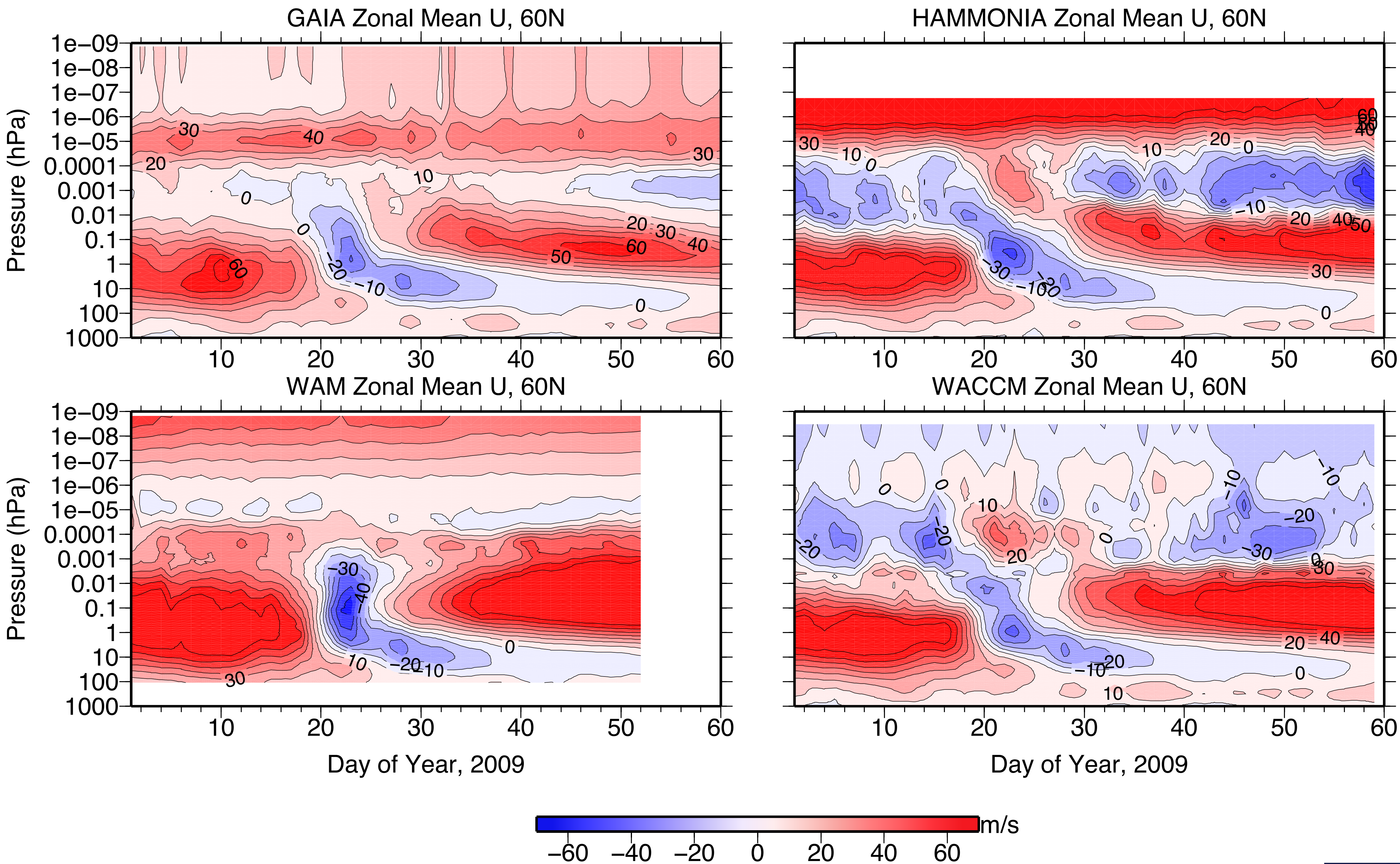
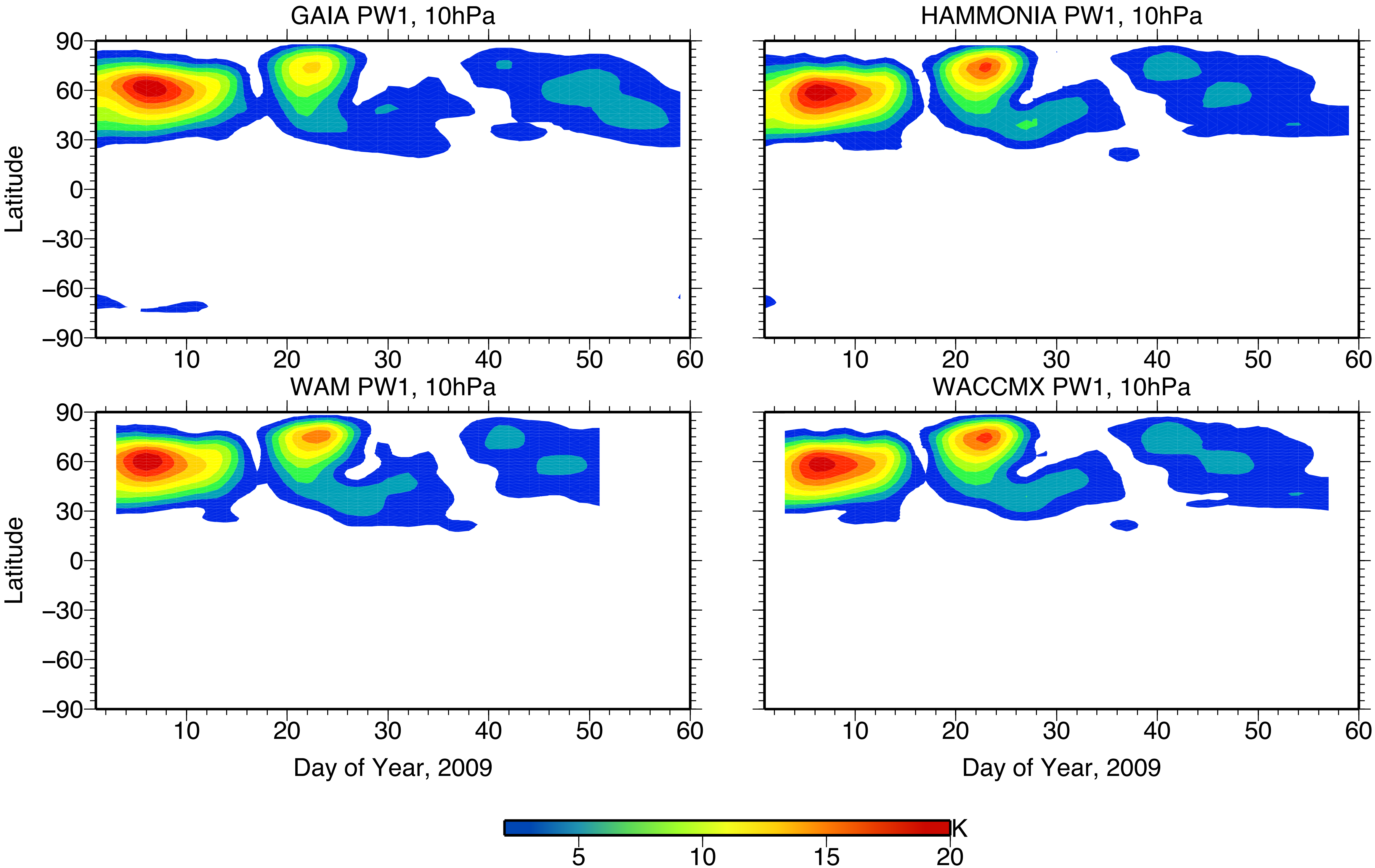


The gravity wave drag differences will also influence the temporal variability during the SSW

The zonal mean dynamics are similar up to ~0.01 hPa. Above this altitude the models are unconstrained and begin to diverge due to different model parameterizations



The planetary wave variability is similar among all models at lower altitudes, but significant differences emerge above the constrained region



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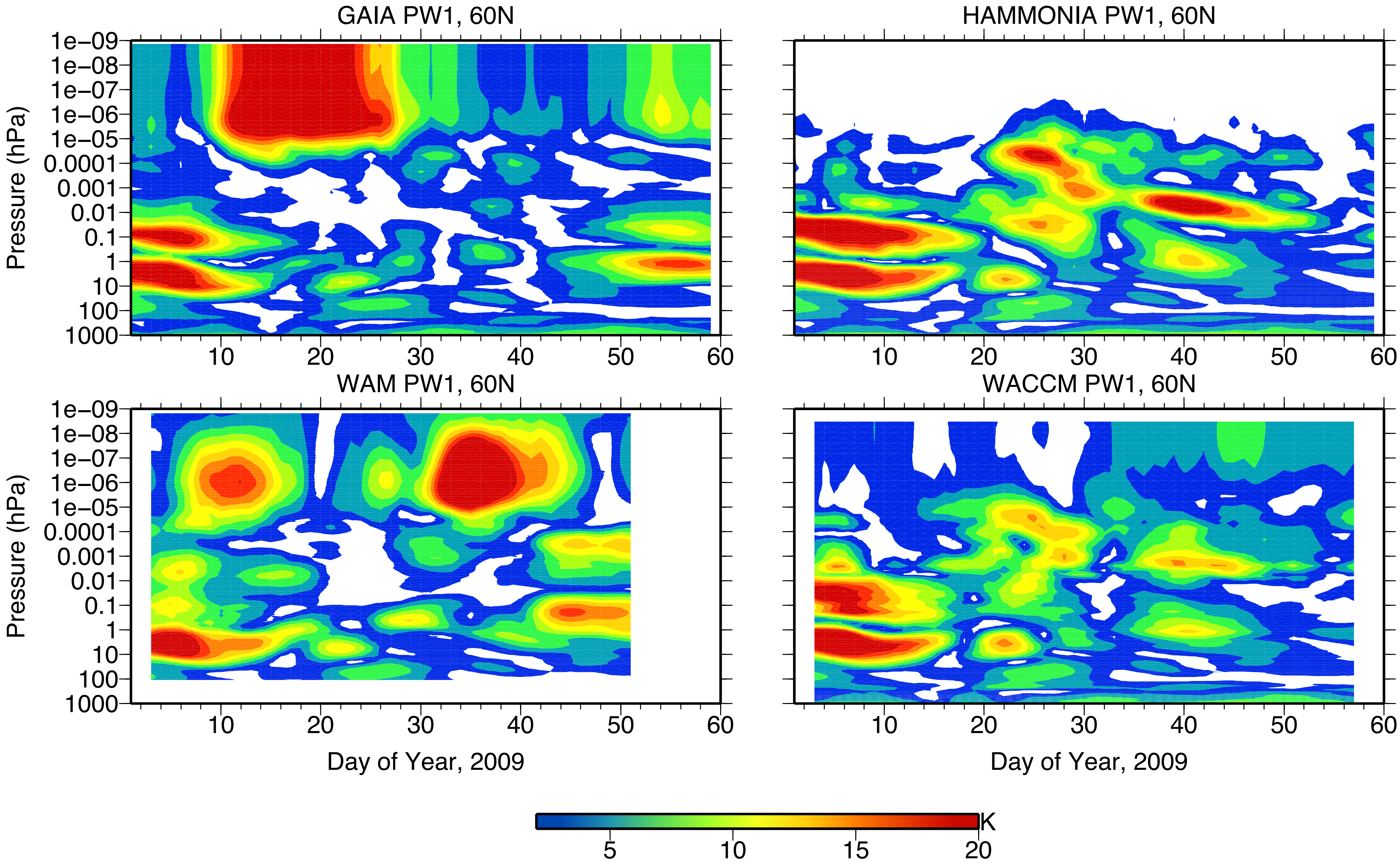

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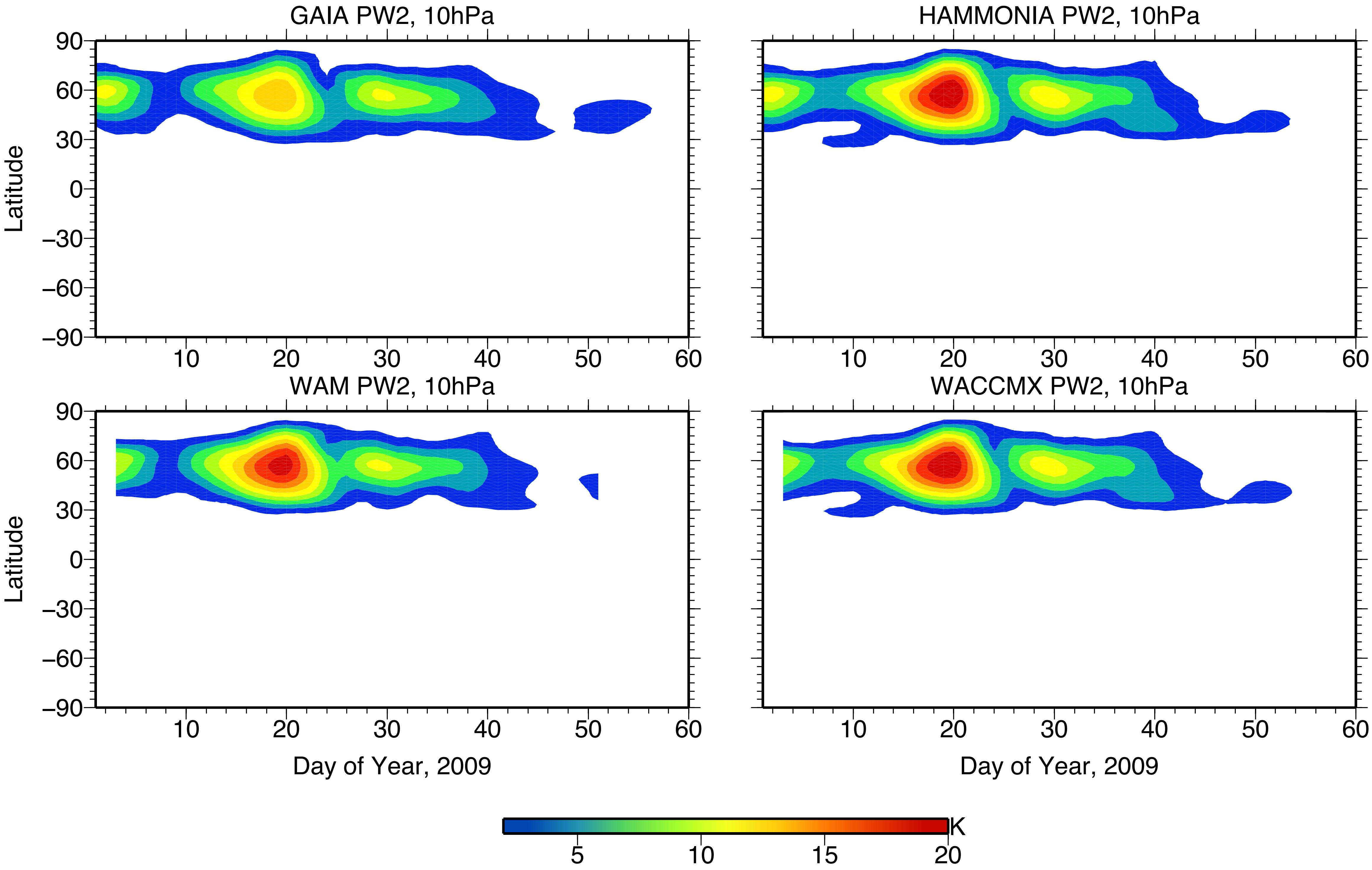

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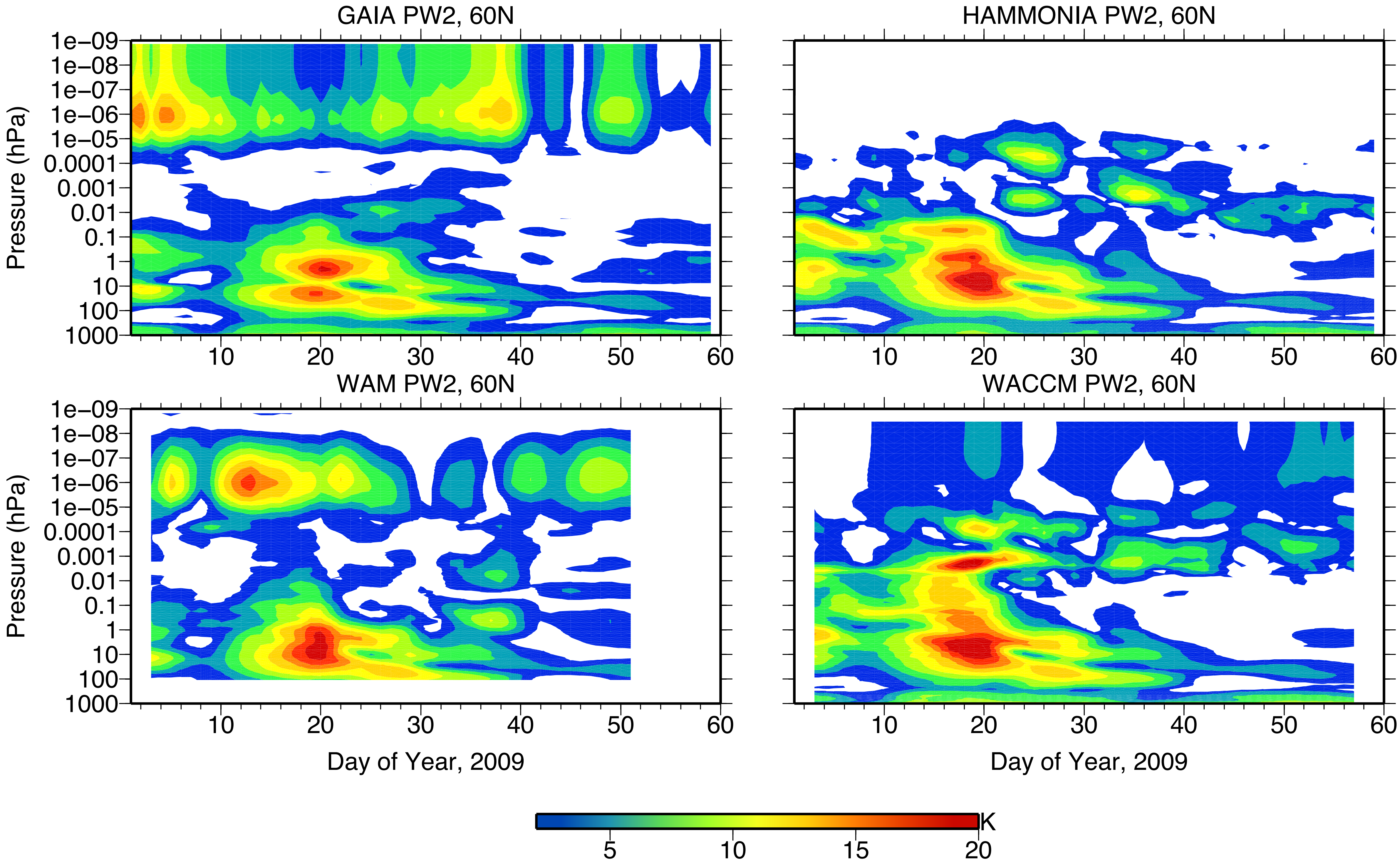
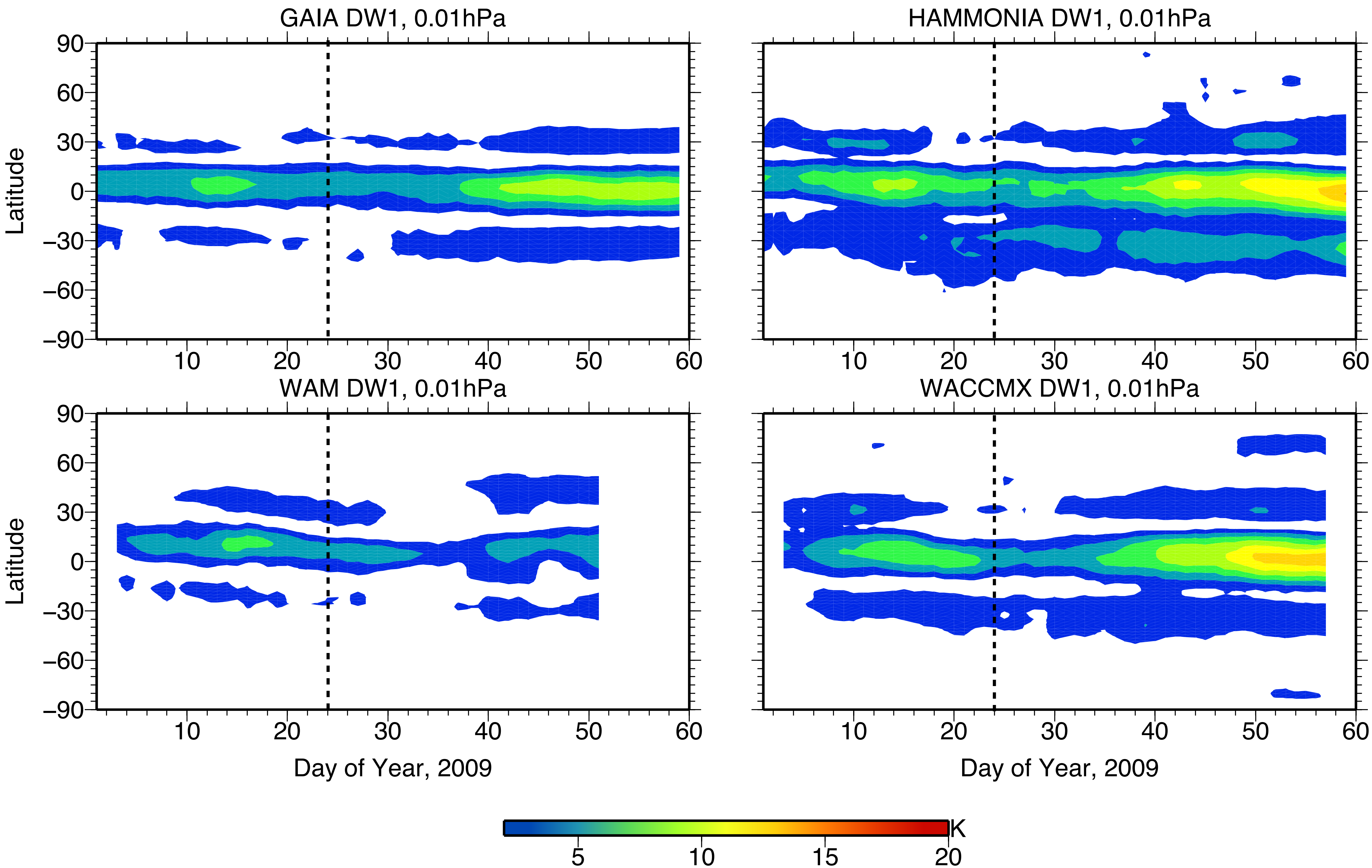
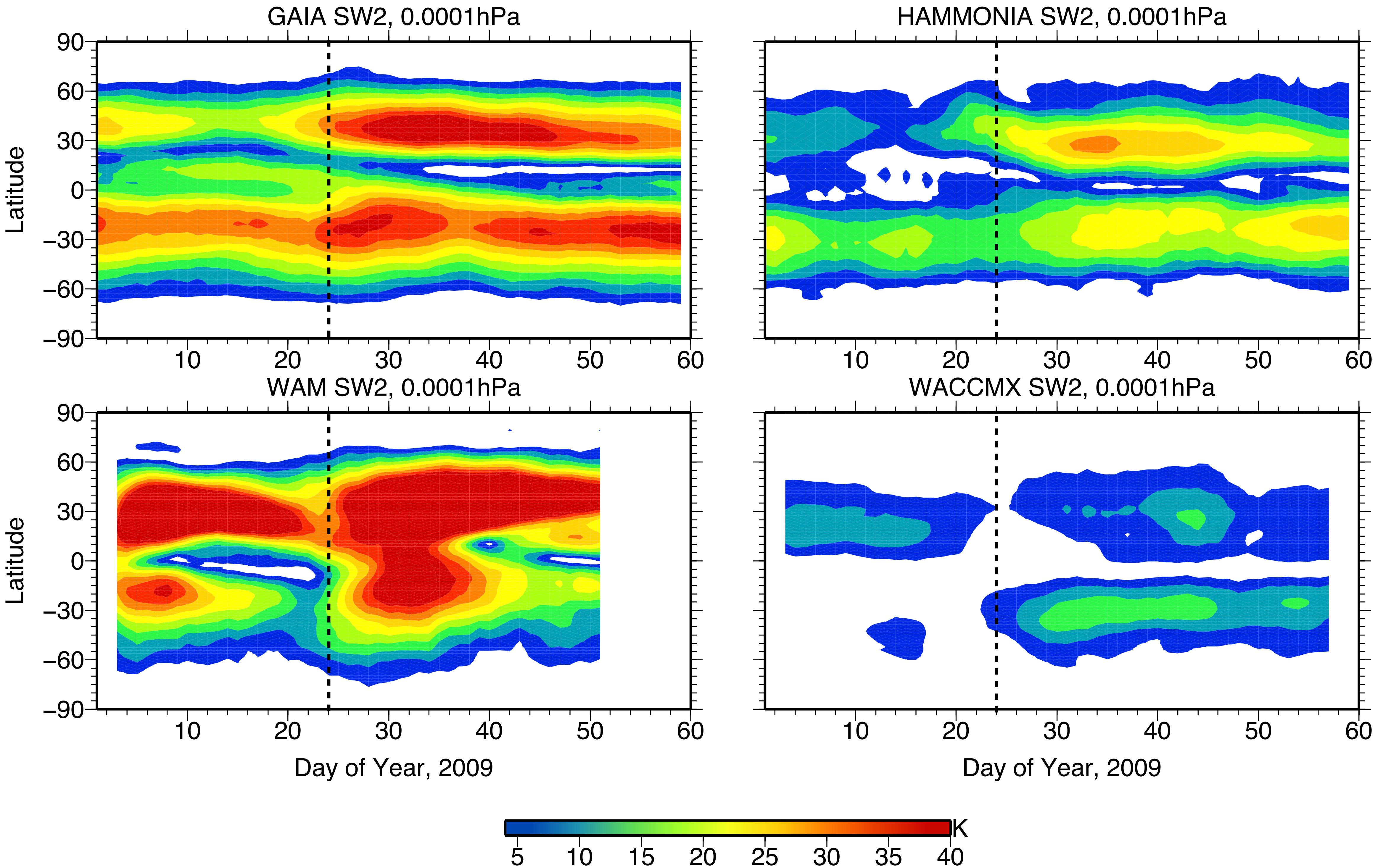


All of the models show similar amplitude and temporal variability of the migrating diurnal tide near 80 km



Significant differences are apparent in the migrating semidiurnal tide. However, all models reveal a decrease prior to the SSW onset, followed by an increase in the SW2 amplitude



Summary and Conclusions

- The neutral dynamics during the 2009 SSW have been compared in four different whole atmosphere models.
- The models exhibit significant differences in the zonal mean zonal wind climatology and SSW induced variability due primarily to the use of different gravity wave parameterizations.
- Although all four models have similar planetary wave variability in the stratosphere, notable differences are apparent in the planetary waves in the mesosphere and lower thermosphere.
- The amplitude and temporal variability of the migrating diurnal tide is similar among all models.
- All four models exhibit generally similar temporal variability for the migrating semidiurnal tide; however, the amplitudes are significantly different.

The influence of atmospheric tide and planetary wave variability during SSWs on the low latitude ionosphere

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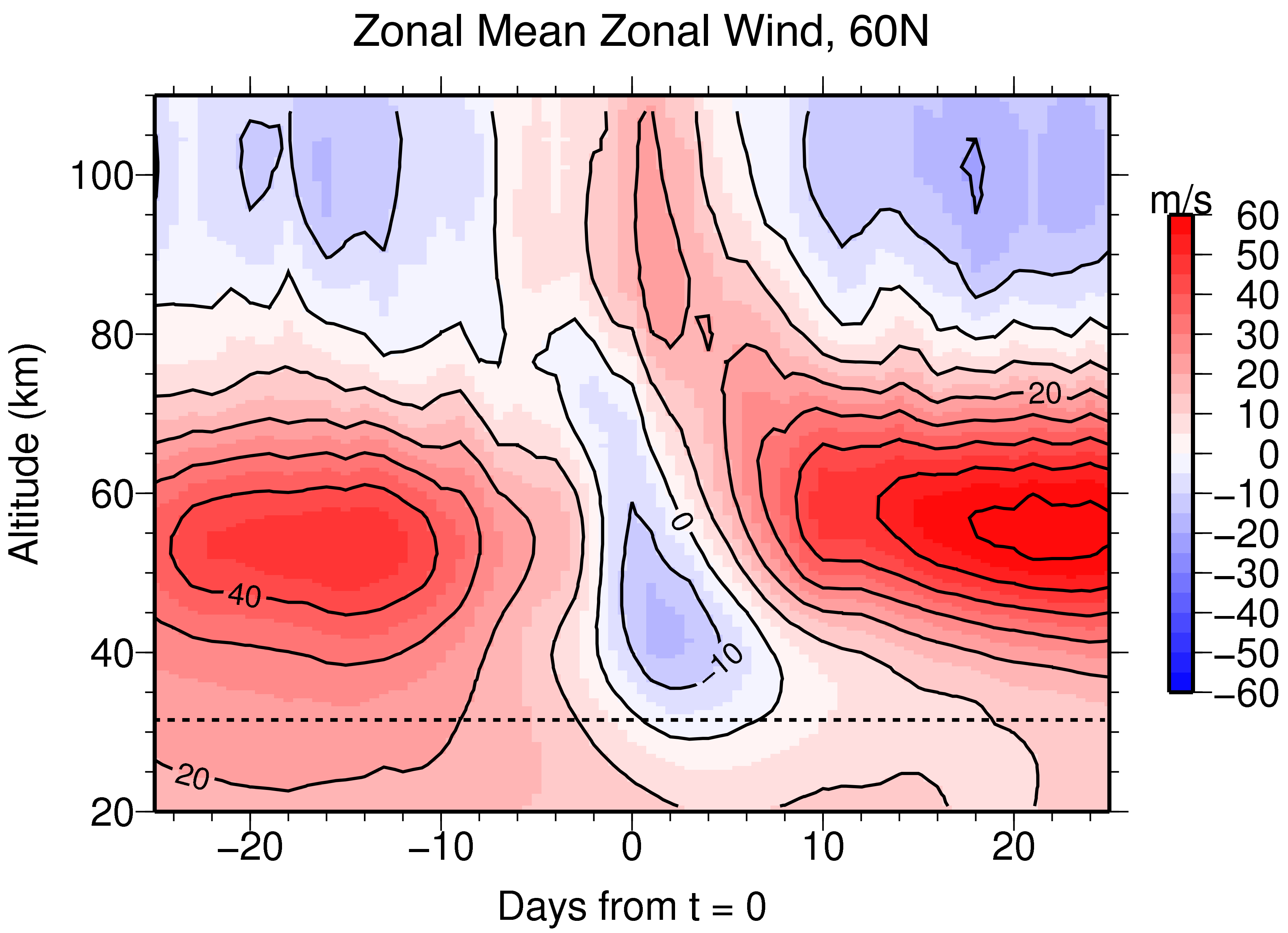
TIME-GCM Simulations

- Idealized simulations in TIME-GCM were performed to study the influence of solar and lunar tides on ionosphere variability during SSWs
- All simulations use the same zonal mean variability due to the SSW, but include different tide and planetary waves at the lower boundary
  - Runs with and without lunar tides
  - Runs with and without planetary waves
  - Runs with different lunar ages relative to the zero epoch of the SSW
  - Constant and temporally varying tides at the TIME-GCM lower boundary
- Simulation setup allows study of how the changes in the zonal mean atmosphere influence the tidal propagation into the MLT
- All results are for the same zonal mean SSW, and we are thus able to isolate the role of different tides and planetary waves on the ionosphere
- SSW variability is based on composite of SSWs in WACCM simulations

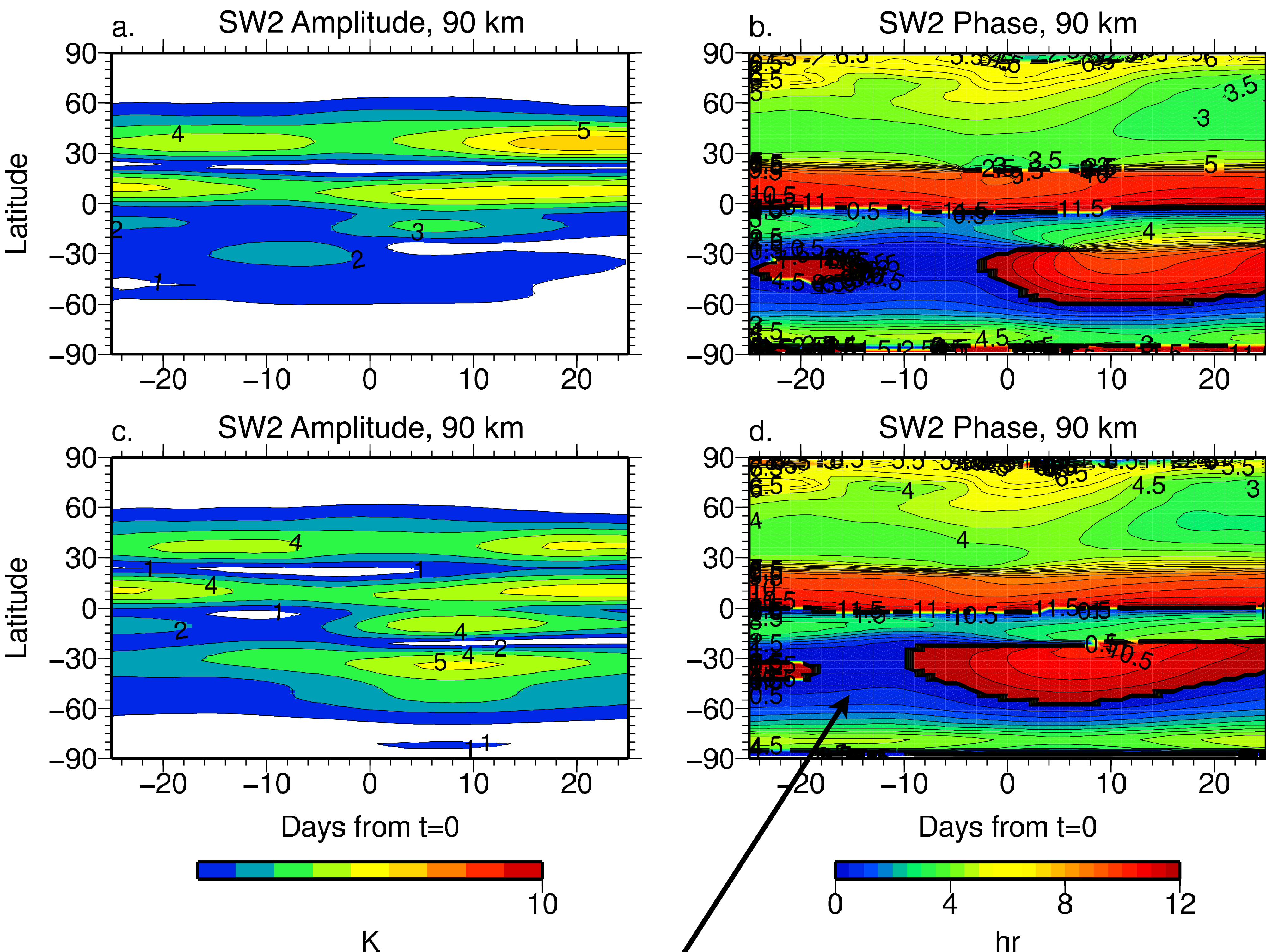
Zonal mean variability for composite SSW



Significant variability occurs in the SW2 due to the influence of the zonal mean atmosphere on tidal propagation

Temporally varying tides at 10hPa

Constant tides at 10 hPa



SW2 Phase variability due to change in vertical wavelength

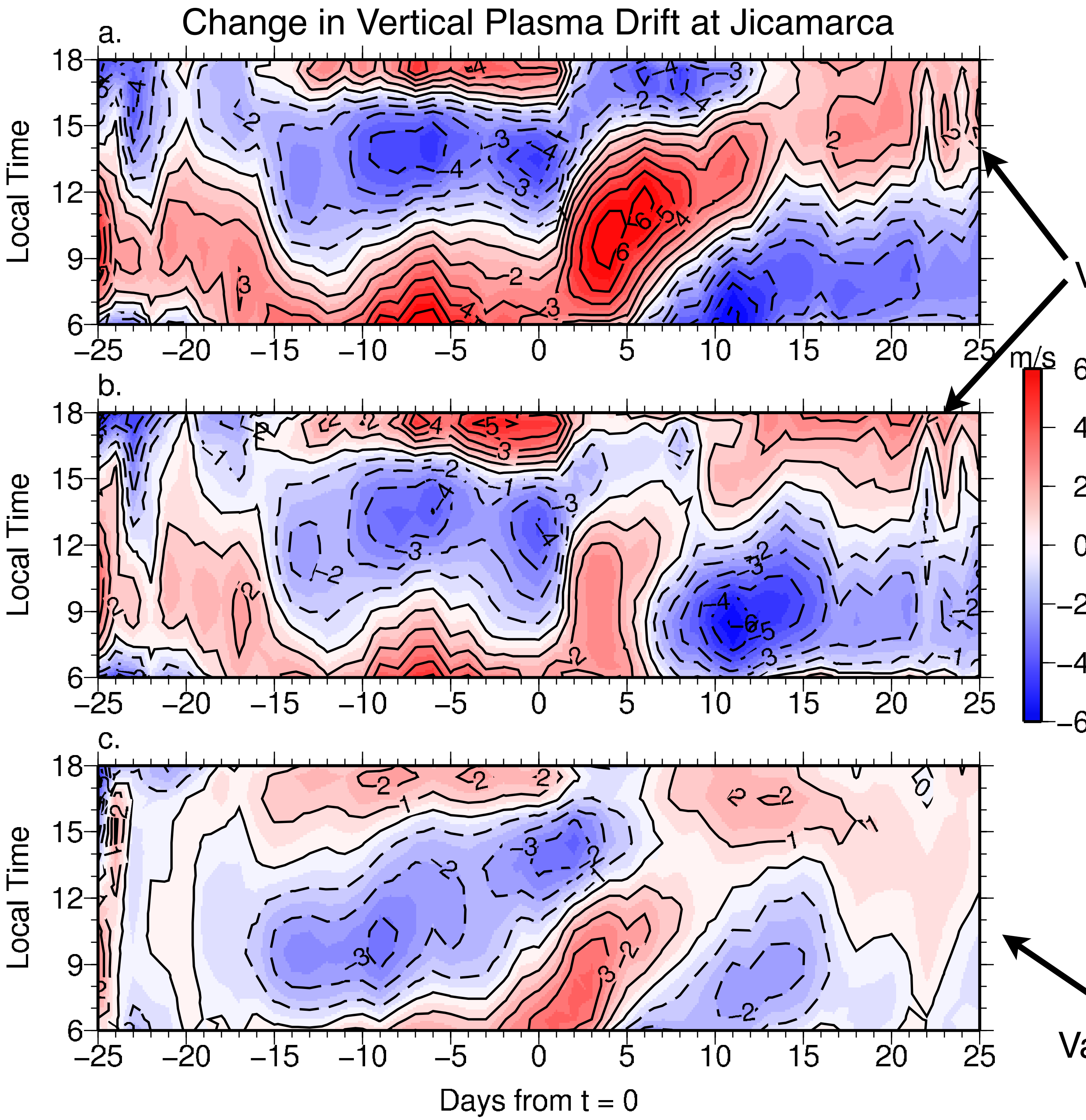
HAO

Change in SW2 amplitude and phase can generate temporal plasma drift variability similar to the observations

Temporally varying tides at 10hPa

Constant tides at 10 hPa

Constant tides at 10 hPa (no PWs)



Variability primarily due to SW2+SW1

Variability primarily due to SW2

The lunar tide contributes to ~30% of the ionosphere variability during SSWs. Overall impact depends on the phase of the moon relative to the SSW