Whole-atmosphere/ionosphere modeling at NOAA: Recent progress and plans

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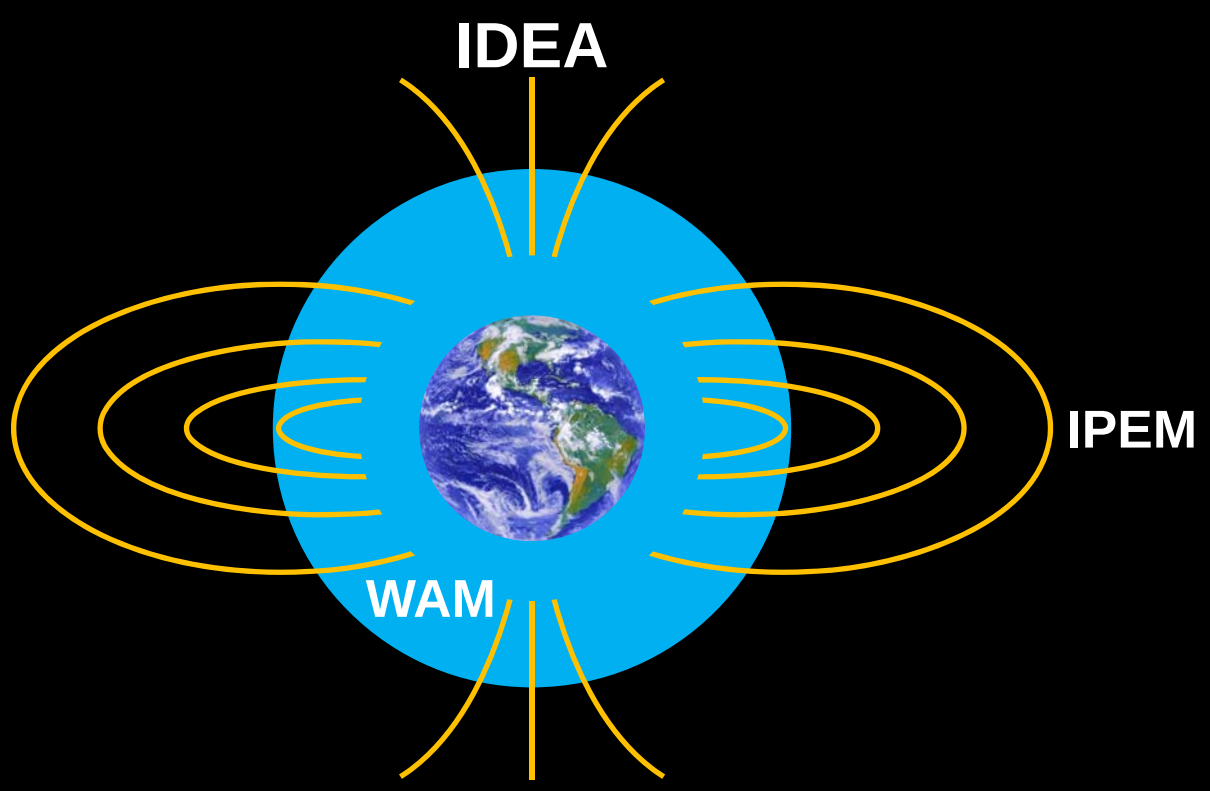
IDEA = WAM + IPM

Everybody talks about the (space) weather...

Integrated Dynamics in Earth's Atmosphere (IDEA) project: To simulate and forecast the effects of terrestrial weather on the ionosphere with interactively coupled Whole Atmosphere and Ionosphere Plasmasphere Electrodynamics models



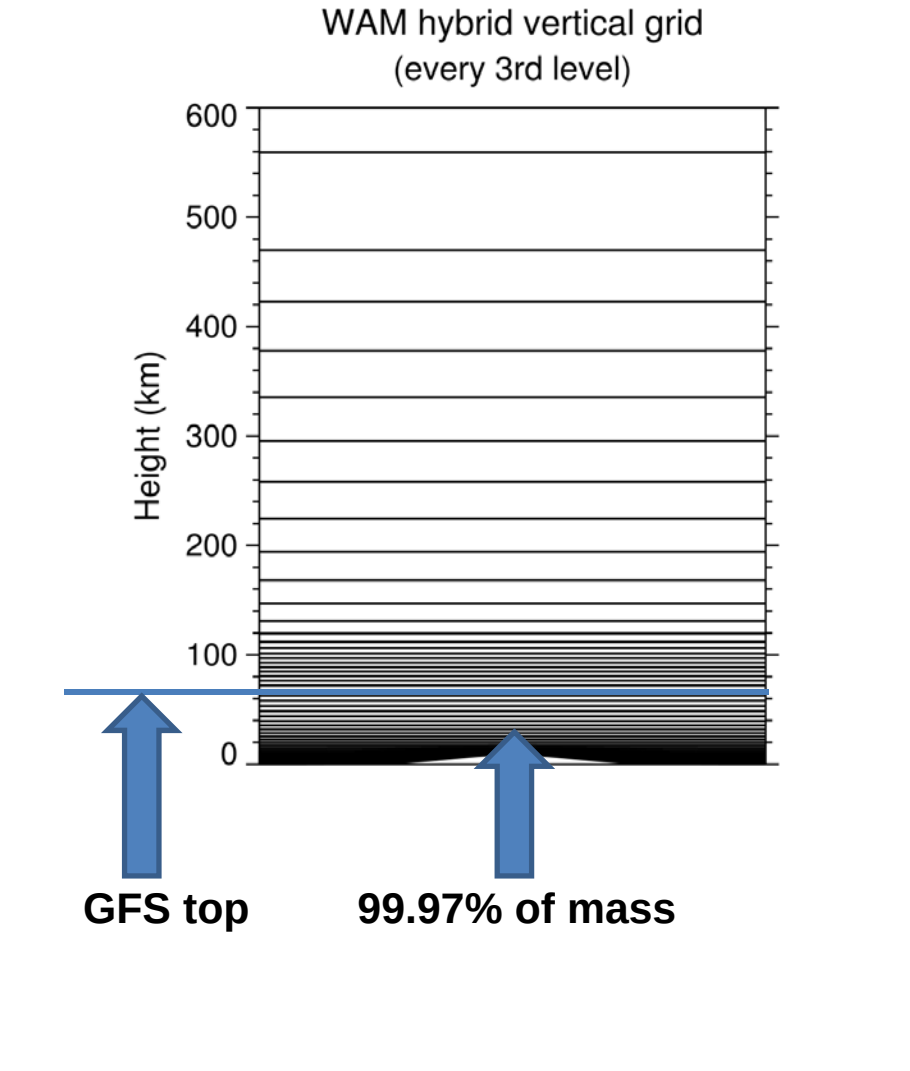
WAM = Extended GFS

Whole Atmosphere Model

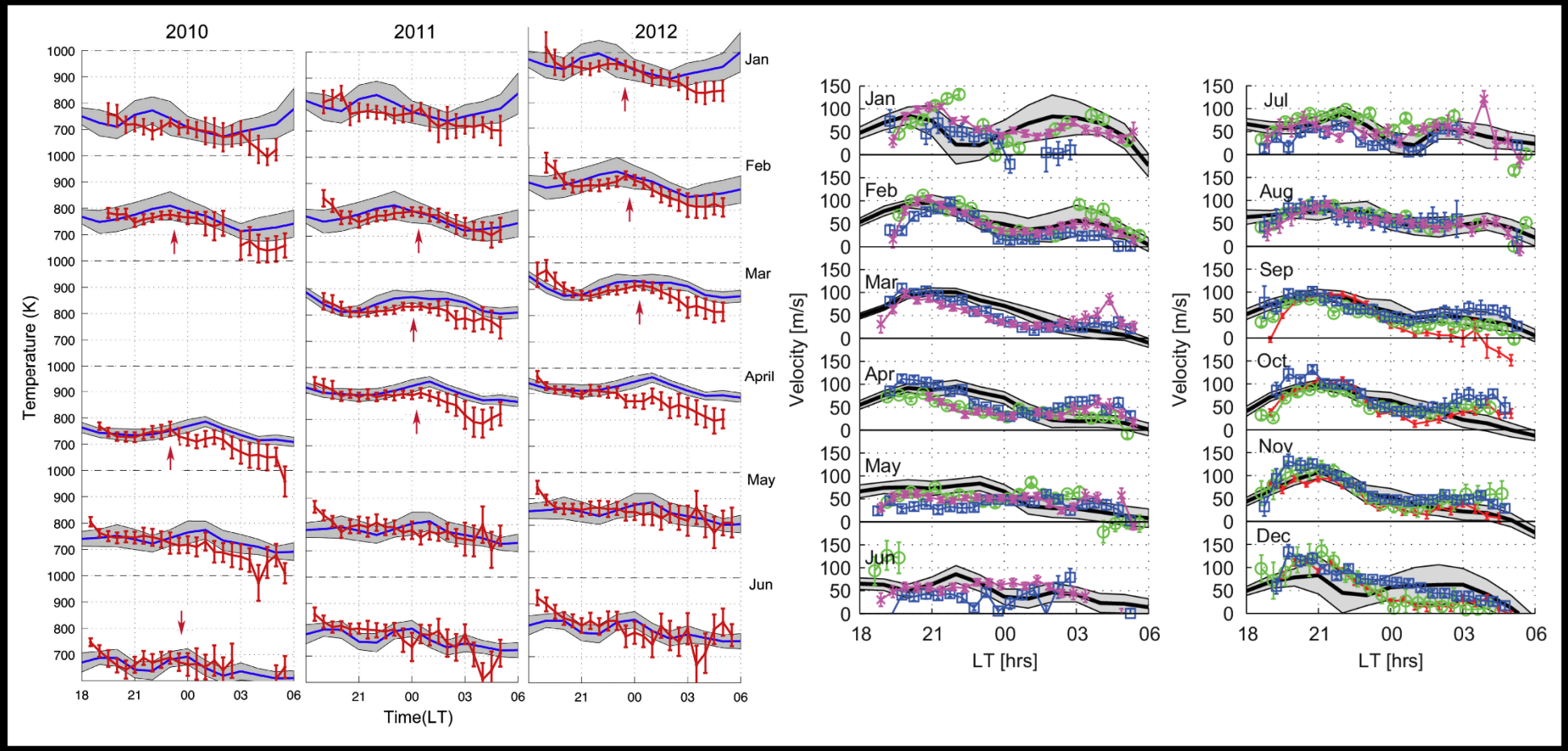
- p_{top} = 1.5×10^{-7} Pa
- T62L150 (~ 2°×2°, ~ 0 – 600 km)
- Free or A/F cycle (WDAS) runs
- Composition dependent *R* & C_p
- Height dependent *g(z)*
- Timing ~ 5.5 min/day on 32 CPUs

Physics

- Horizontal & vertical mixing (no "sponge")
- Radiative heating: EUV, UV, & non-LTE IR
- Empirical ionosphere & electric fields: ion drag & Joule heating
- Major species composition

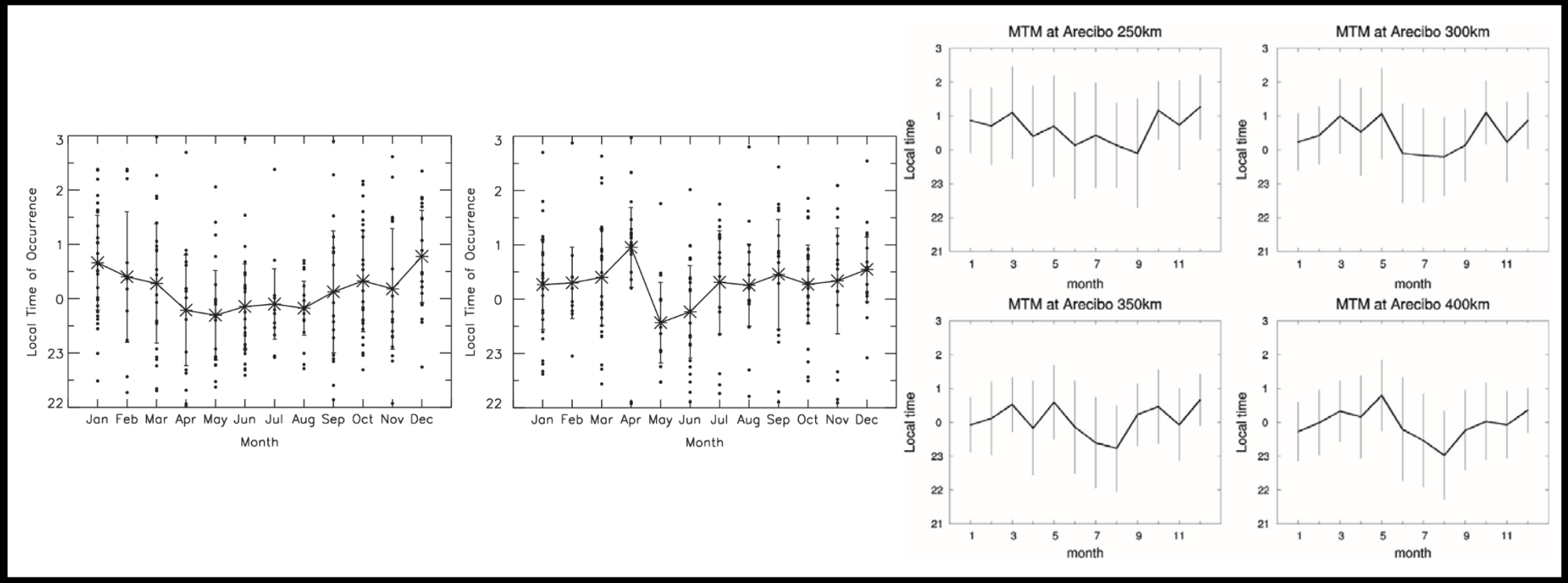


Midnight T maximum (MTM) in equatorial Brazil (7ºS)



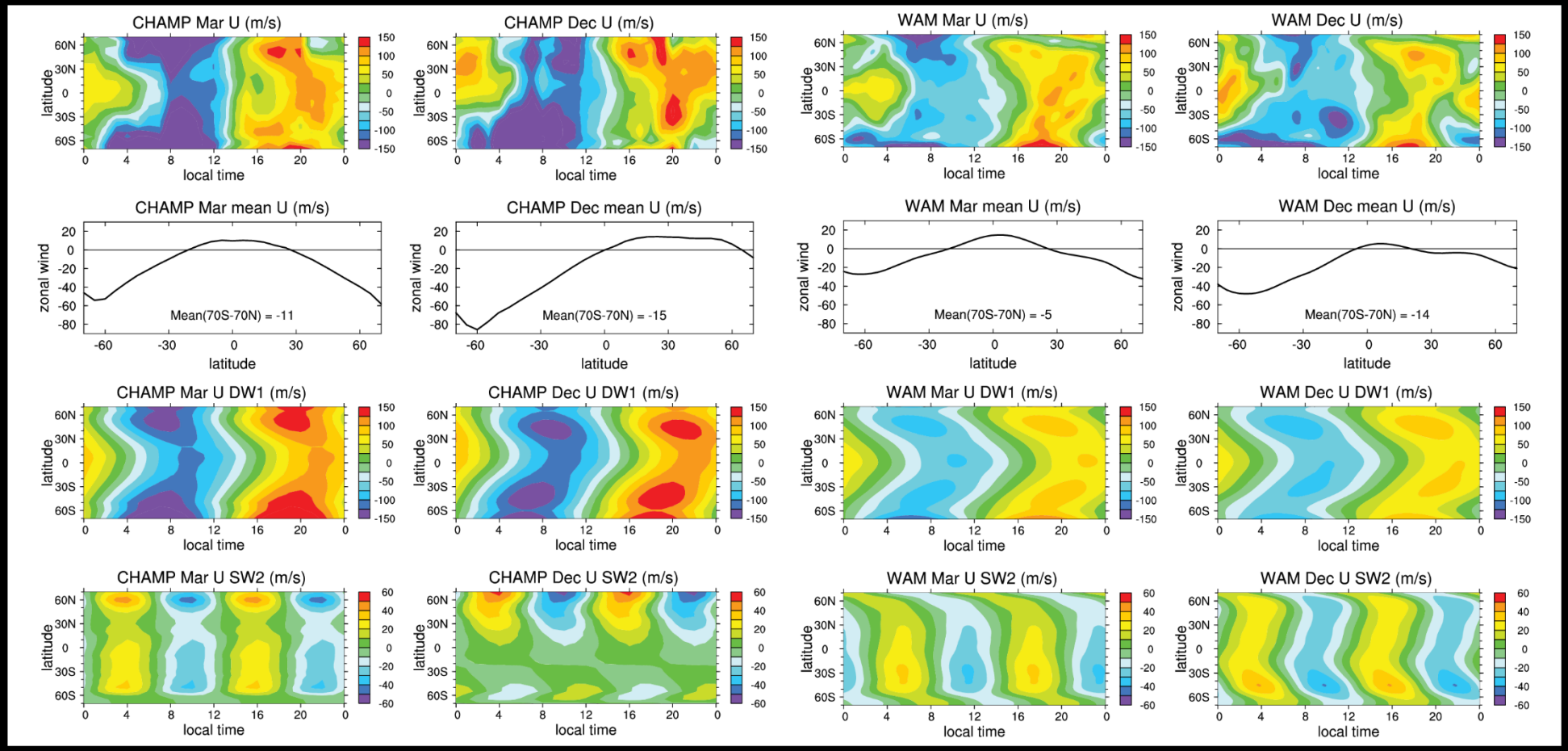
Comparison of T (left) and U (right) with ground-based FPI observations at ~ 240 km (Meriwether et al., JASTP, 2013).

MTM timing at Arecibo (18ºN)



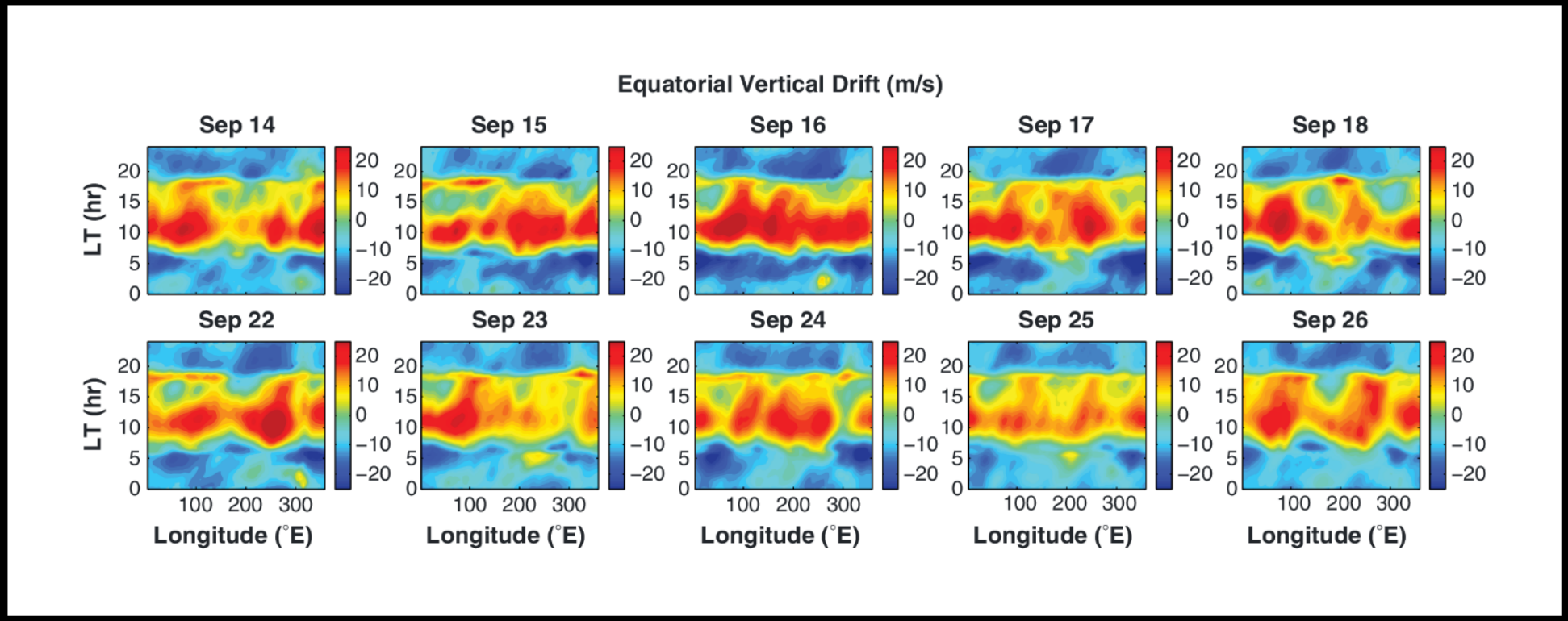
Comparison of MTM timing: (left) ISR at 330 and 367 km and (right) WAM (Martinis et al., JASTP, 2013).

Global CHAMP U at ~400 km



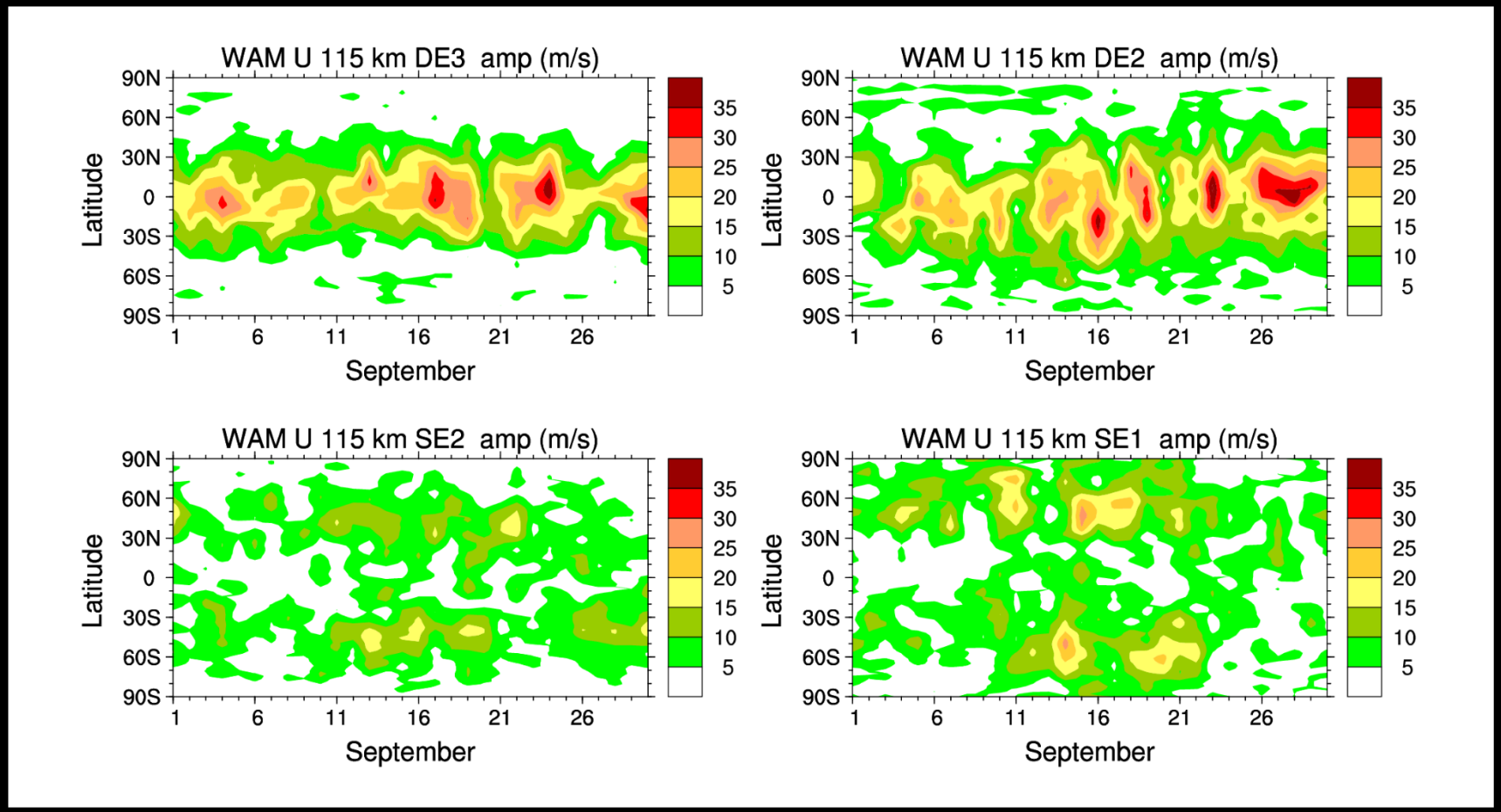
Comparison of CHAMP (left) and WAM (right) U, zonal mean, DW1 and SW2 tides at ~ 400 km (Lieberman et al., GRL, 2013).

Ionospheric drift: Variability



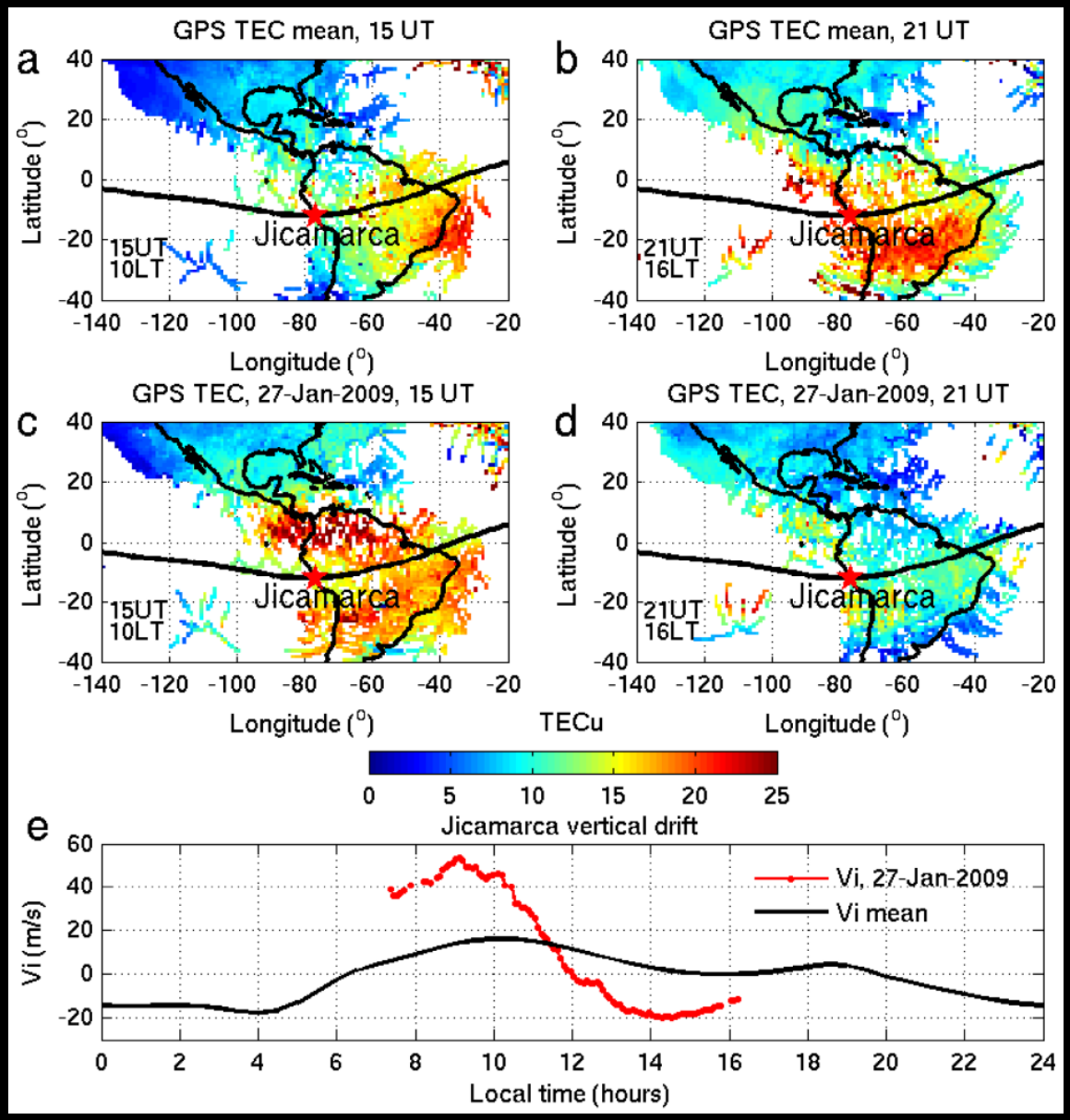
Example of a free running WAM driving GIP for September: Daily variation of longitudinal structure of equatorial plasma drifts (Fang et al., GRL, 2013).

Nonmigrating tides: Variability



Nonmigrating diurnal tides DE2 and DE3 create alternating three- and four-peak structures in the drift on different days (Fang et al., 2013).

January 2009 sudden stratospheric warming



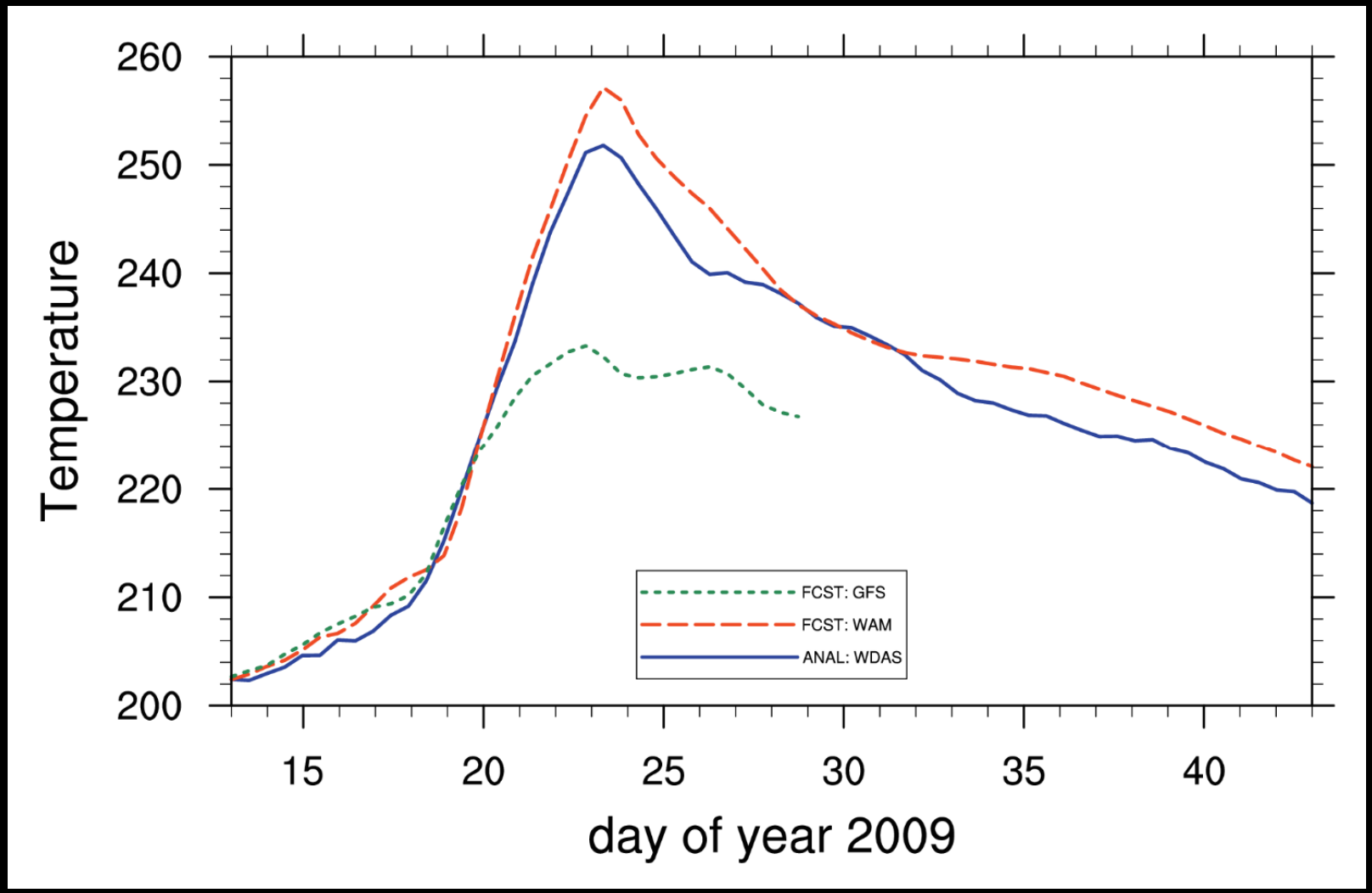
Goncharenko et al. (2010):

Climatological TEC @ 10 and 16 LT from ground GPS observations.

Same on January 27, after the peak of the warming.

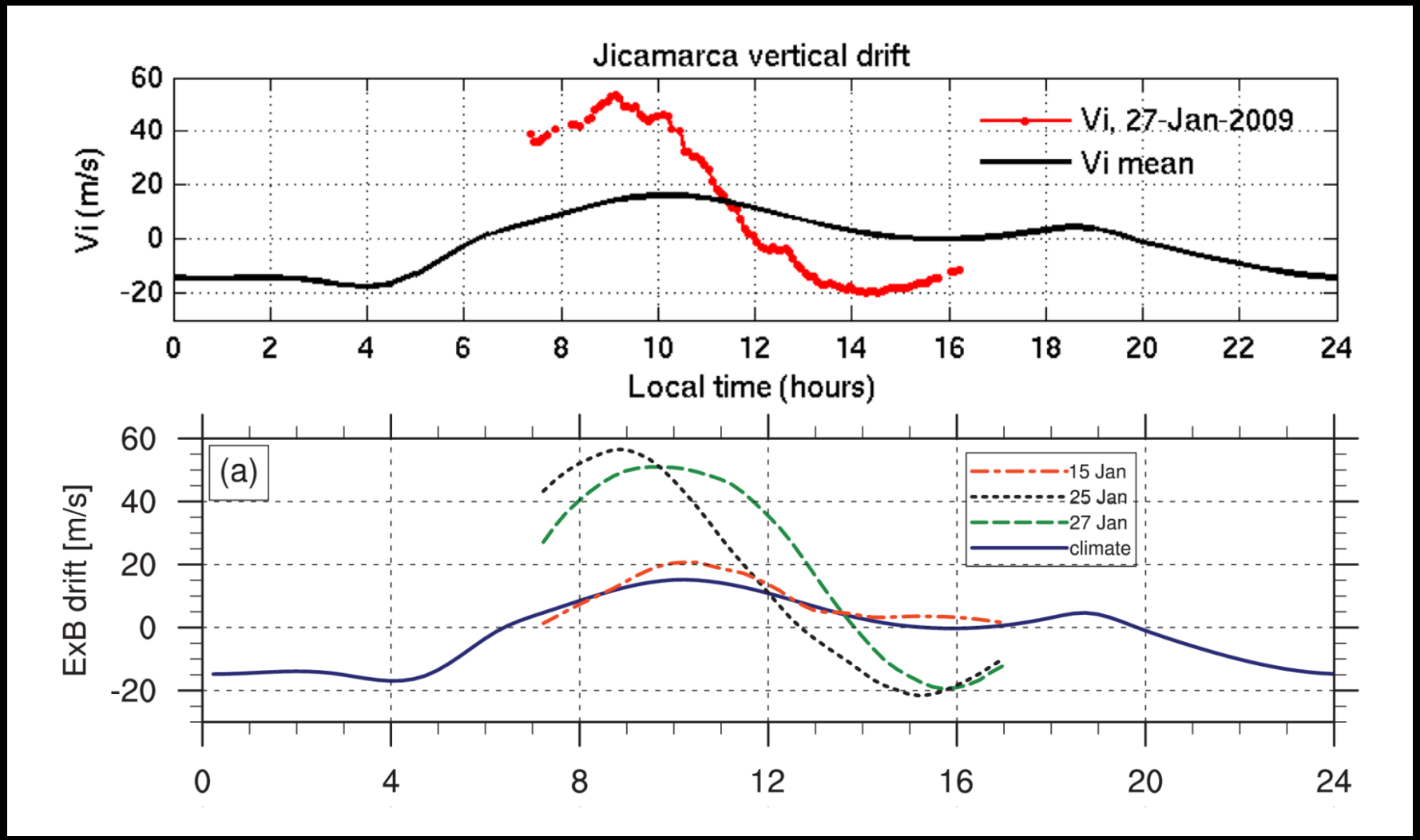
Comparison of plasma drift climatology with observations on Jan. 27.

2009 SSW: IDEA/WAM forecast v GFS



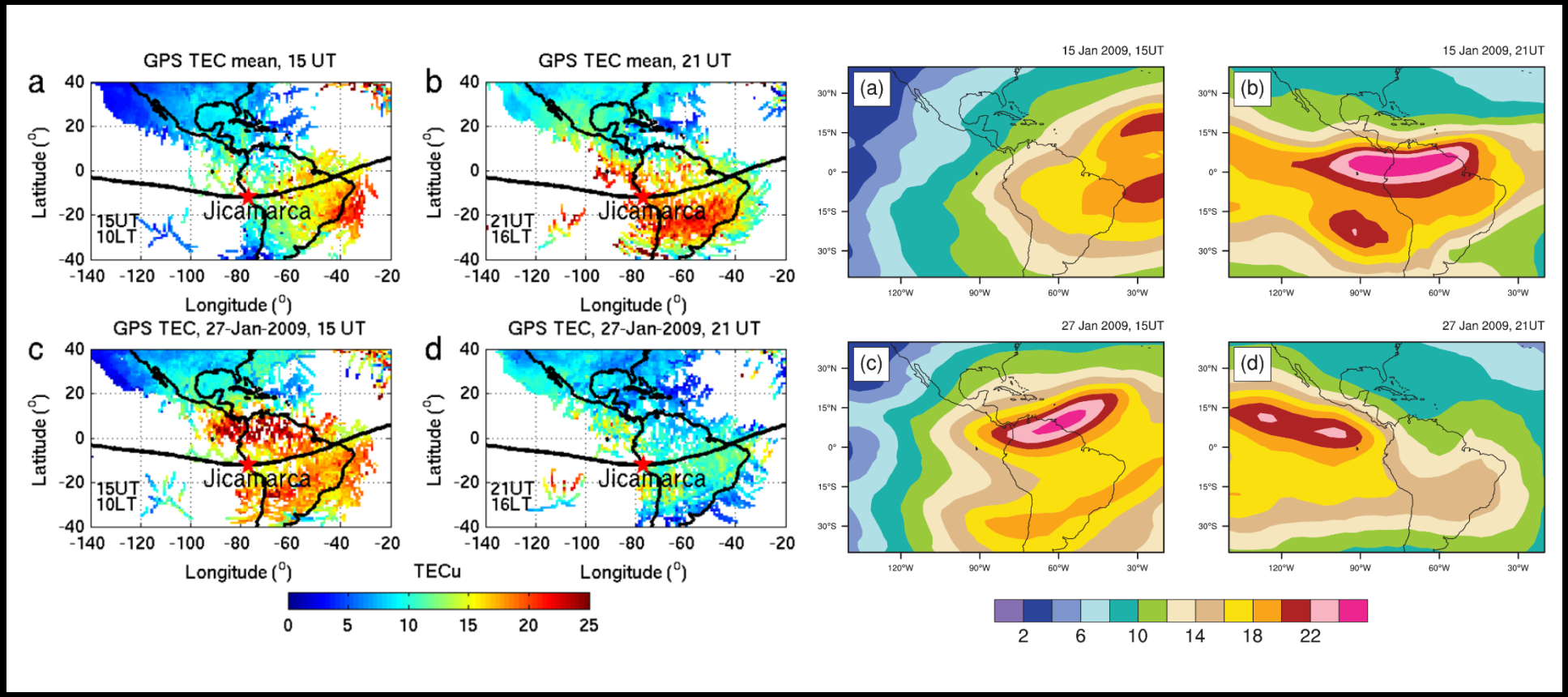
Initialized with WDAS analysis of operational weather data WAM forecasts the SSW (polar cap T at 10 hPa) 10 days in advance (Wang et al., 2014).

2009 SSW: IDEA plasma drift forecast



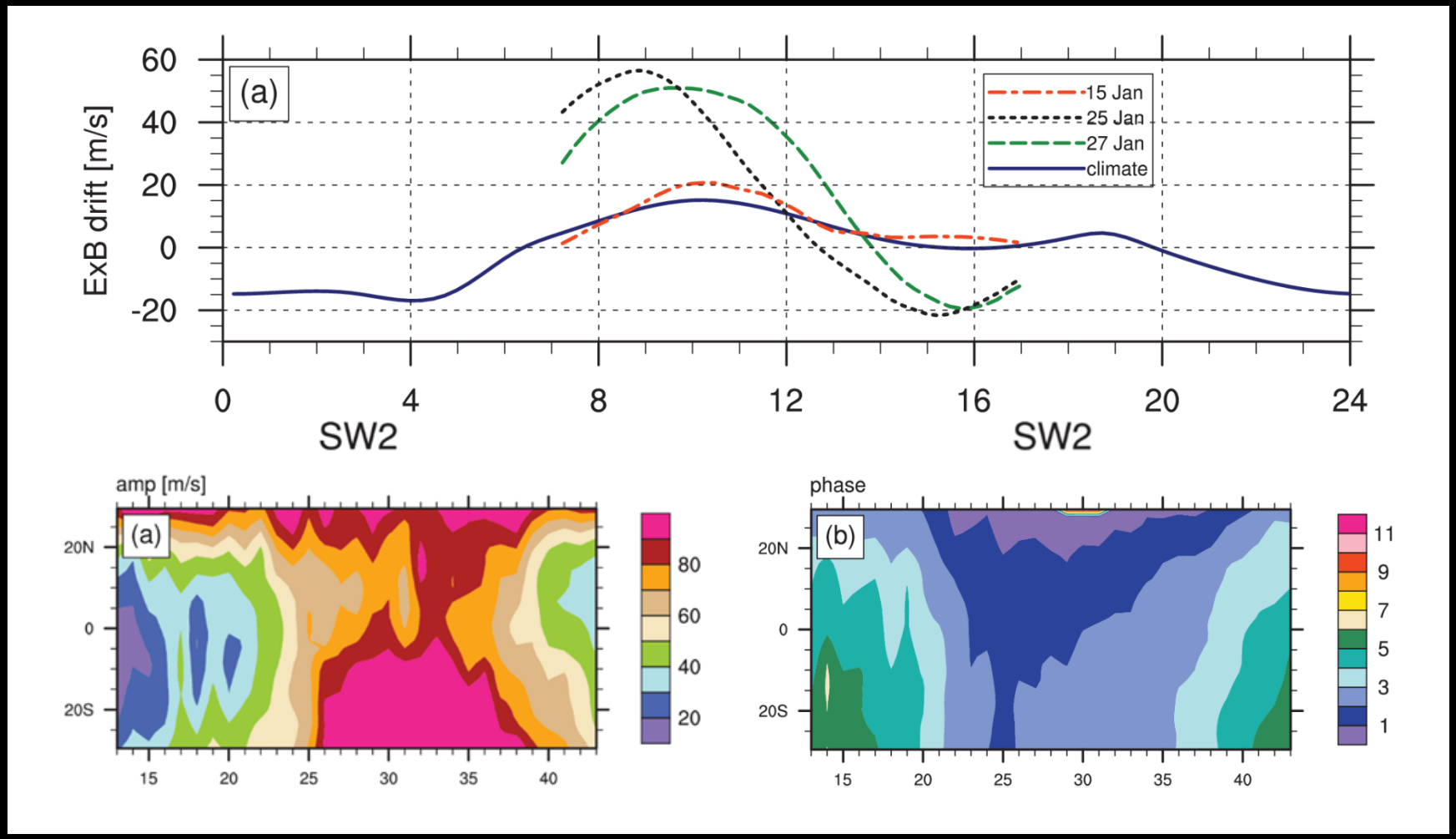
IDEA (WAM+GIP) forecast of plasma drift @ Jicamarca (Wang et al., 2014) compared to observations (Goncharenko et al., 2010).

2009 SSW: IDEA TEC forecast



IDEA (WAM+GIP) 2-week forecast of TEC in the American sector (Wang et al., 2014) vs. observations (Goncharenko et al., 2010).

2009 SSW: Tidal drive of plasma drift changes



IDEA (WAM+GIP) forecast of plasma drift @ Jicamarca v SW2 amplitude and phase @ 115 km (Wang et al., 2014).

Milestones, plans, and challenges

- New version of WAM rebuilt within the NOAA Environmental Modeling System (NEMS)
- FY2015
  - Implement parallel run of WAM (benefits for terrestrial weather?)
  - Test short-range IDEA forecasts
- Future plans and challenges
  - Coupling with a parallel IPEM
  - Forecasting forcing “from above”
  - More realistic formulation of dynamics (e.g., nonhydrostatic, “deep atmosphere”) and physics (e.g., solar-cycle dependent radiation and photochemistry) in WAM
  - …

With contributions by

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- M. Iredell
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