Observations of thermal tides in the atmosphere of Mars by the SPICAM instrument

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Abstract 30.01
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Thermal tides on Mars

- Migrating tides important in the lower atmosphere, observed by landers, infra-red sounders, radio occultation instruments
  - Migrating tides move with the same phase speed as the Sun
  - No variations with longitude at fixed local time
- Non-migrating tides important in the upper atmosphere, observed by aerobraking accelerometer instruments
  - Non-migrating tides do not move with the same phase speed at the Sun
  - Cause variations with longitude at fixed local time

- What happens in the middle atmosphere?

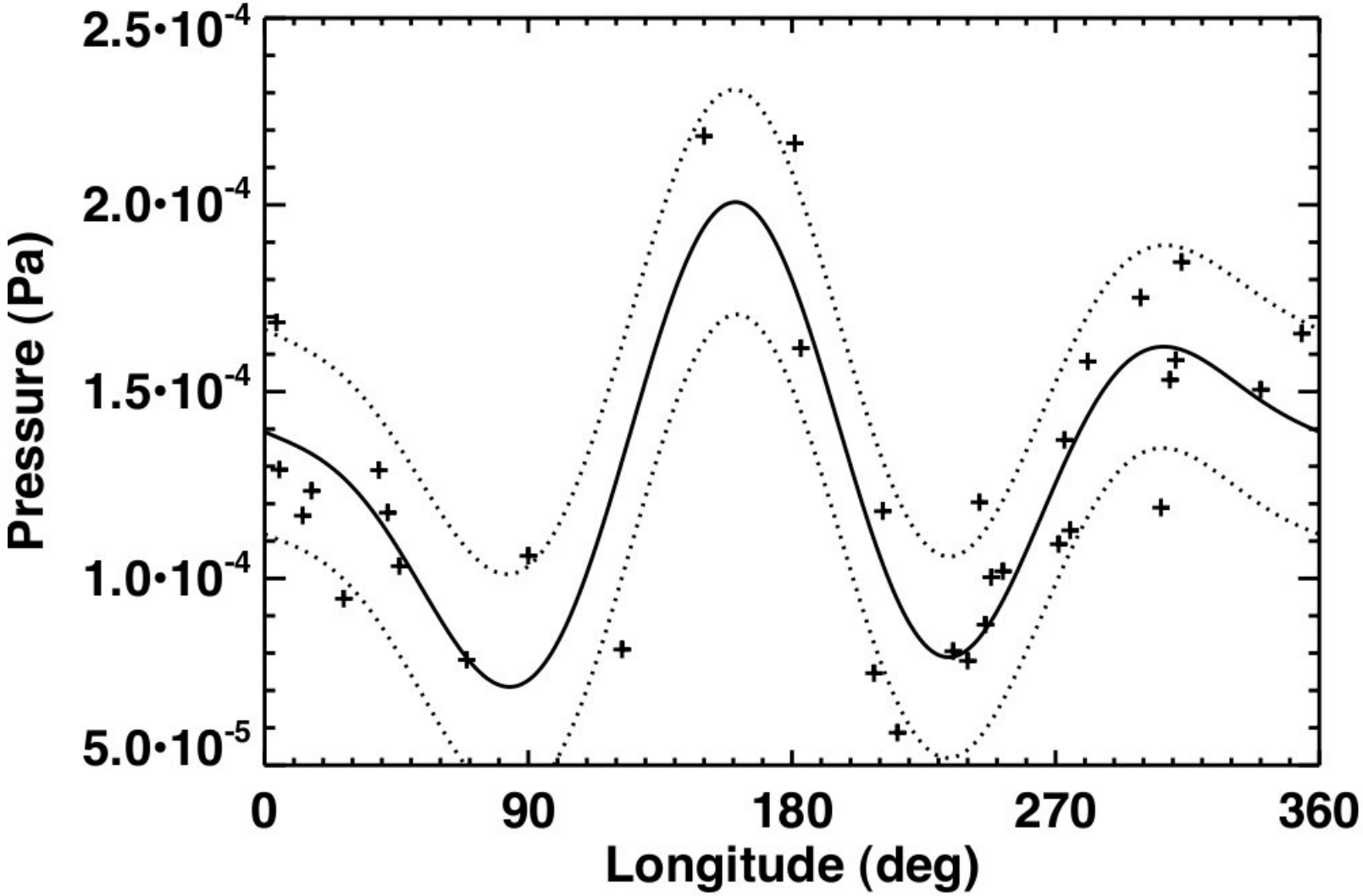
SPICAM

- UV spectrometer on Mars Express
- Observed 100s of stellar occultations and derived vertical density, pressure and temperature profiles from 50 km to 120 km
- We select cases where many SPICAM profiles were obtained at similar latitude, season and local time
- For each case, how do pressure and temperature vary with altitude and longitude?

Selected cases

Label	N	Latitude	Ls	LST (hrs)
2	53	60°S–30°S	90°–120°	1.0–5.0
9	29	15°N–45°N	240°–270°	0.8–3.5
10	34	20°S–10°S	90°–120°	2.6–4.8
11	15	40°N–50°N	0°–50°	2.6–4.8
12	27	40°S–30°S	150°–180°	22–24

We focus on Case 9 in this poster
Cases 10 and 12 are mentioned briefly



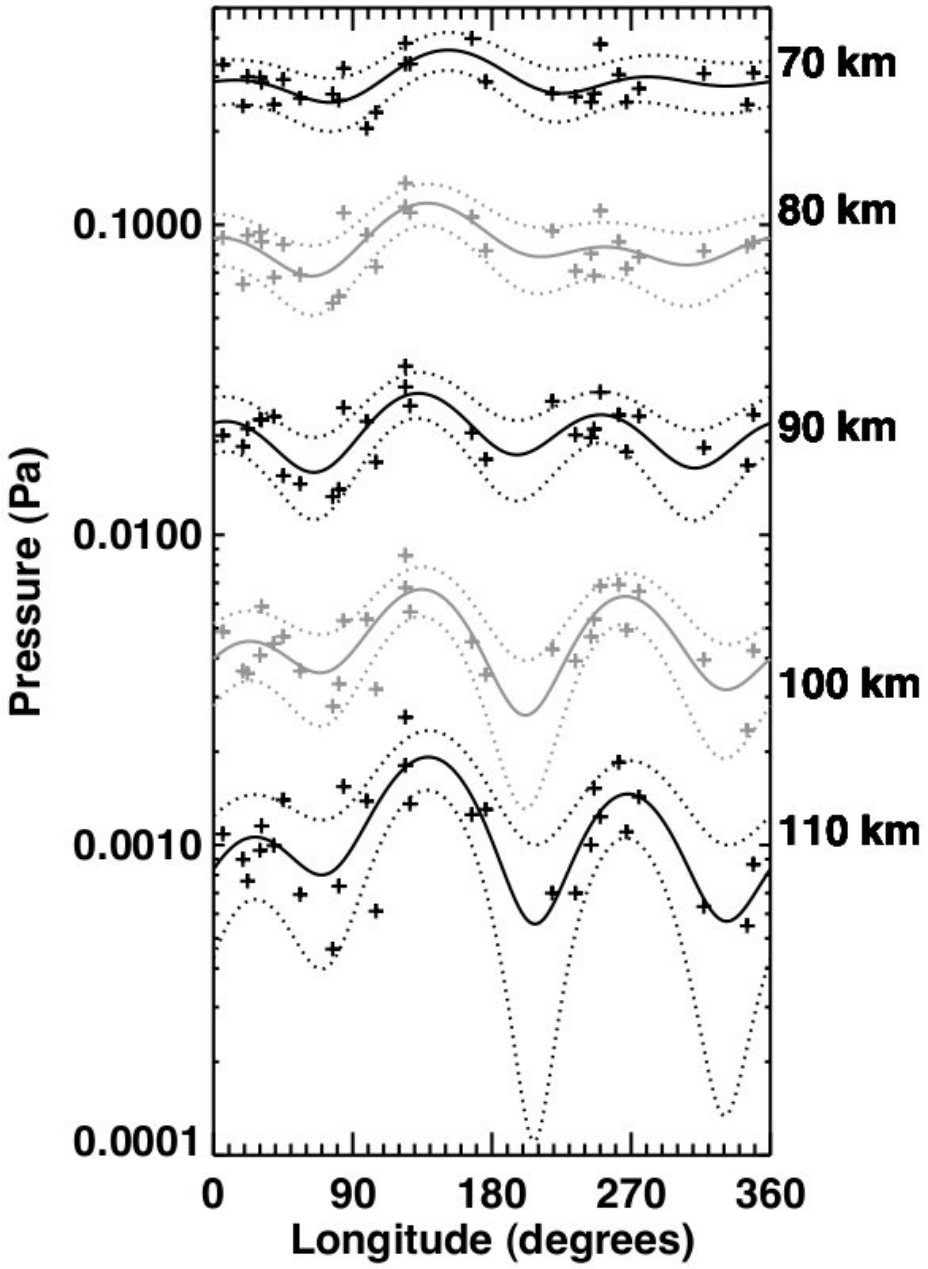
Pressure at 110 km for Case 10

Wave-3 harmonic fit shown here and in subsequent figures

Demonstrates that zonal structure is present in SPICAM observations

Wave-2 component is strong, consistent with aerobraking and other observations

Presumably Diurnal Kelvin wave (DK1)

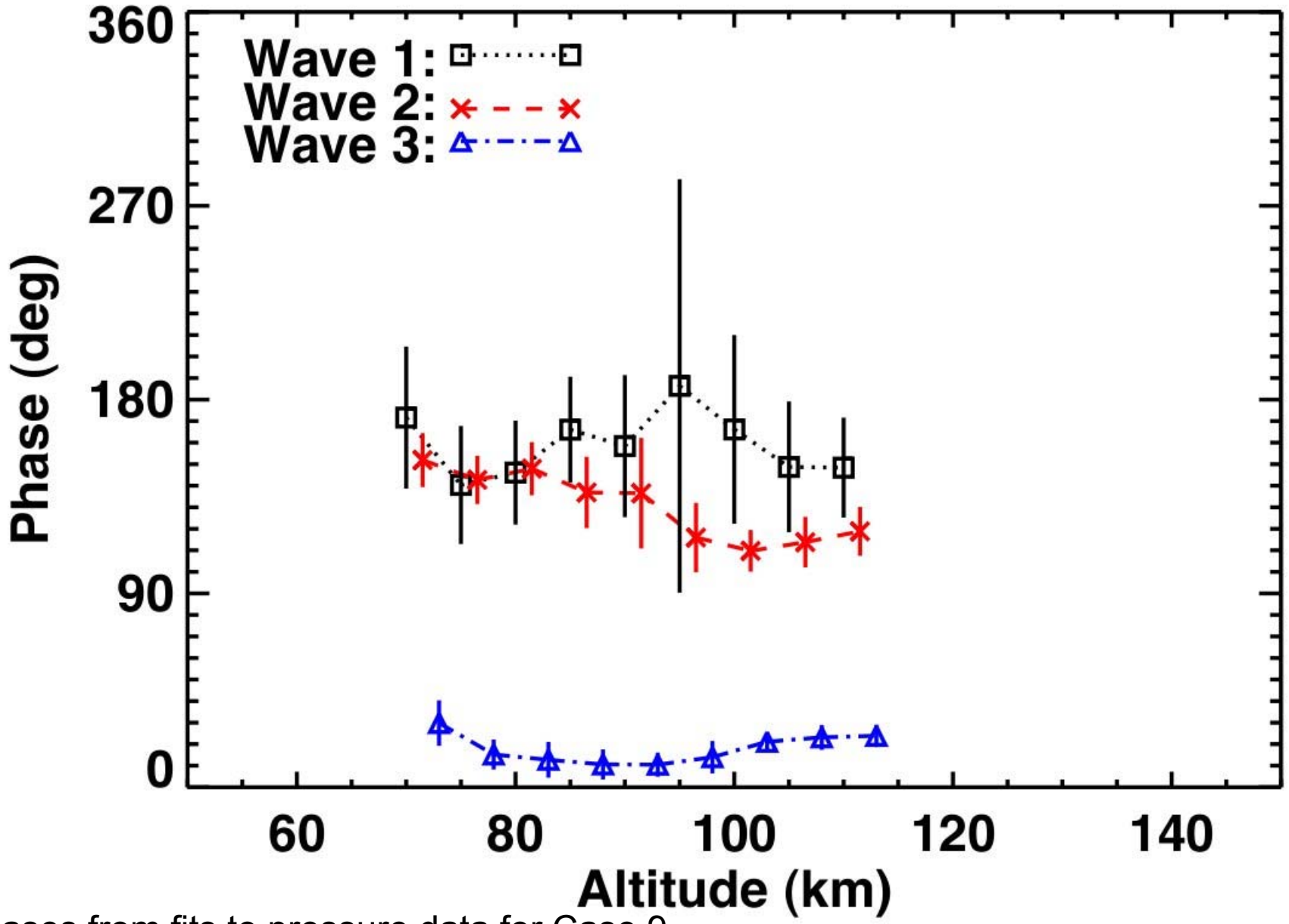


Pressure at 70-110 km for Case 9

Zonal structure is persistent over wide vertical range

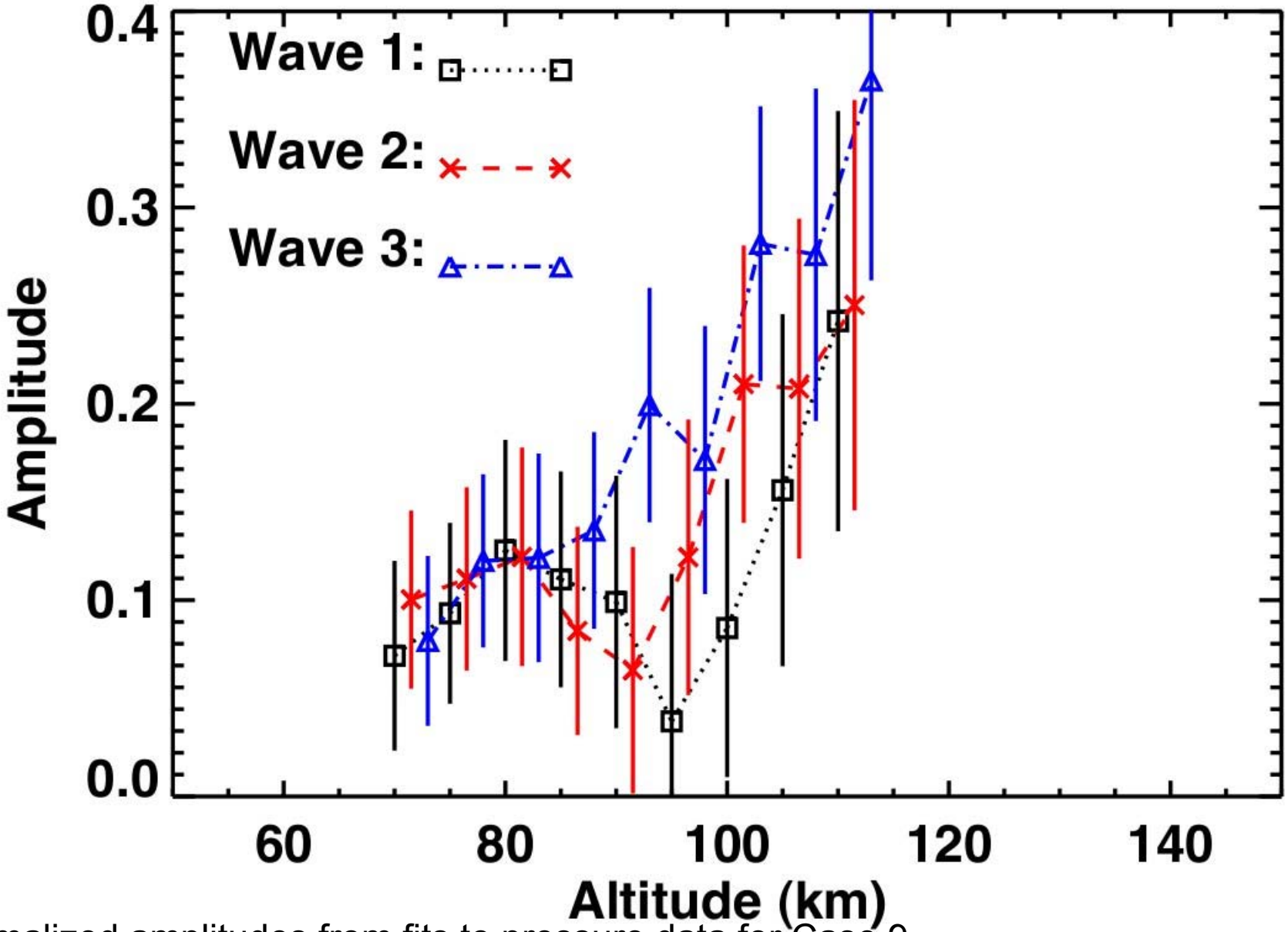
Normalized amplitudes of pressure harmonics increase with increasing altitude

Phases of peaks and troughs are mostly constant with altitude



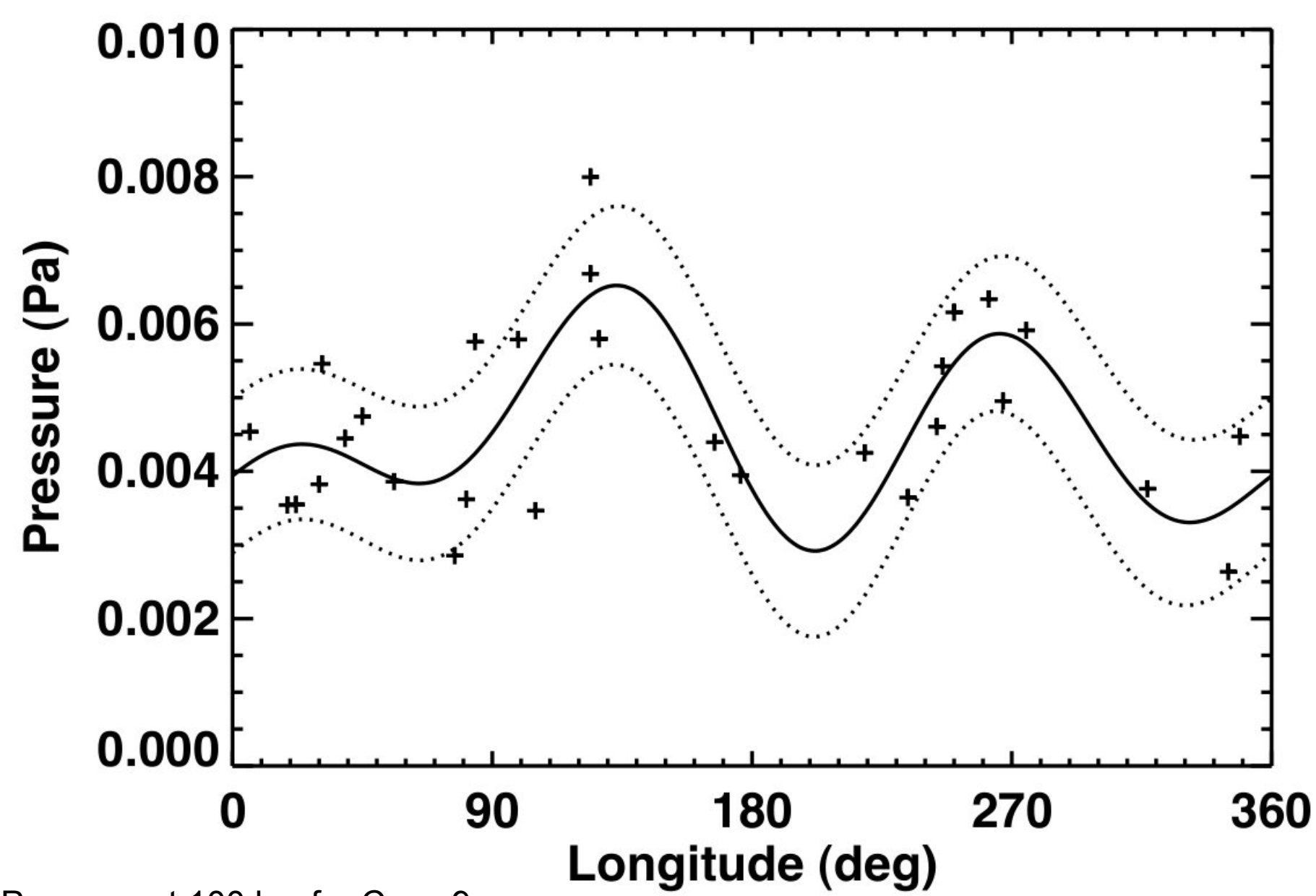
Phases from fits to pressure data for Case 9

Phases are generally steady, perhaps drifting slightly

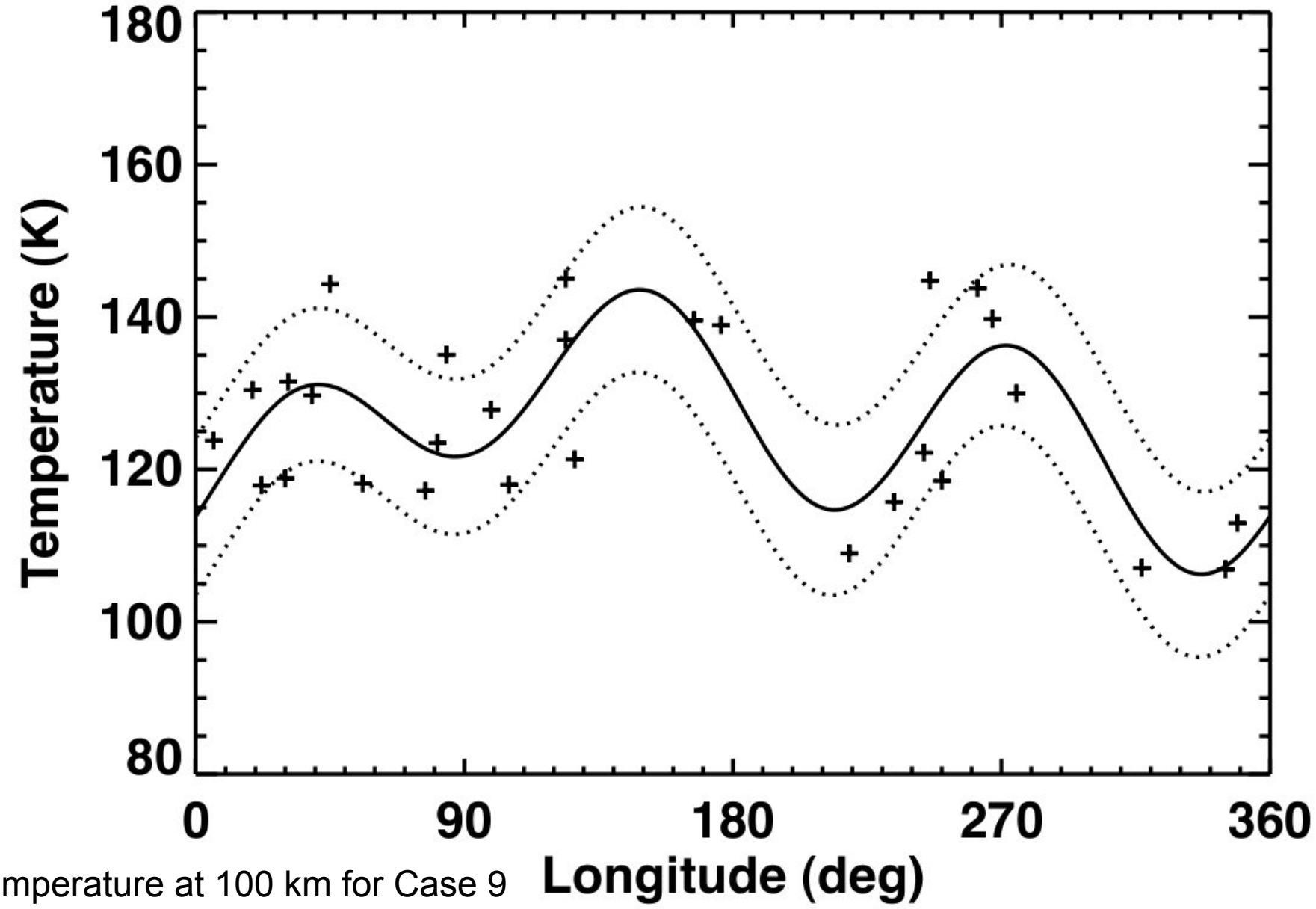


Normalized amplitudes from fits to pressure data for Case 9
Wave 3 (blue) amplitude increases monotonically with increasing altitude
Wave 1 (black) and 2 (red) amplitudes have local minimum at 90 km

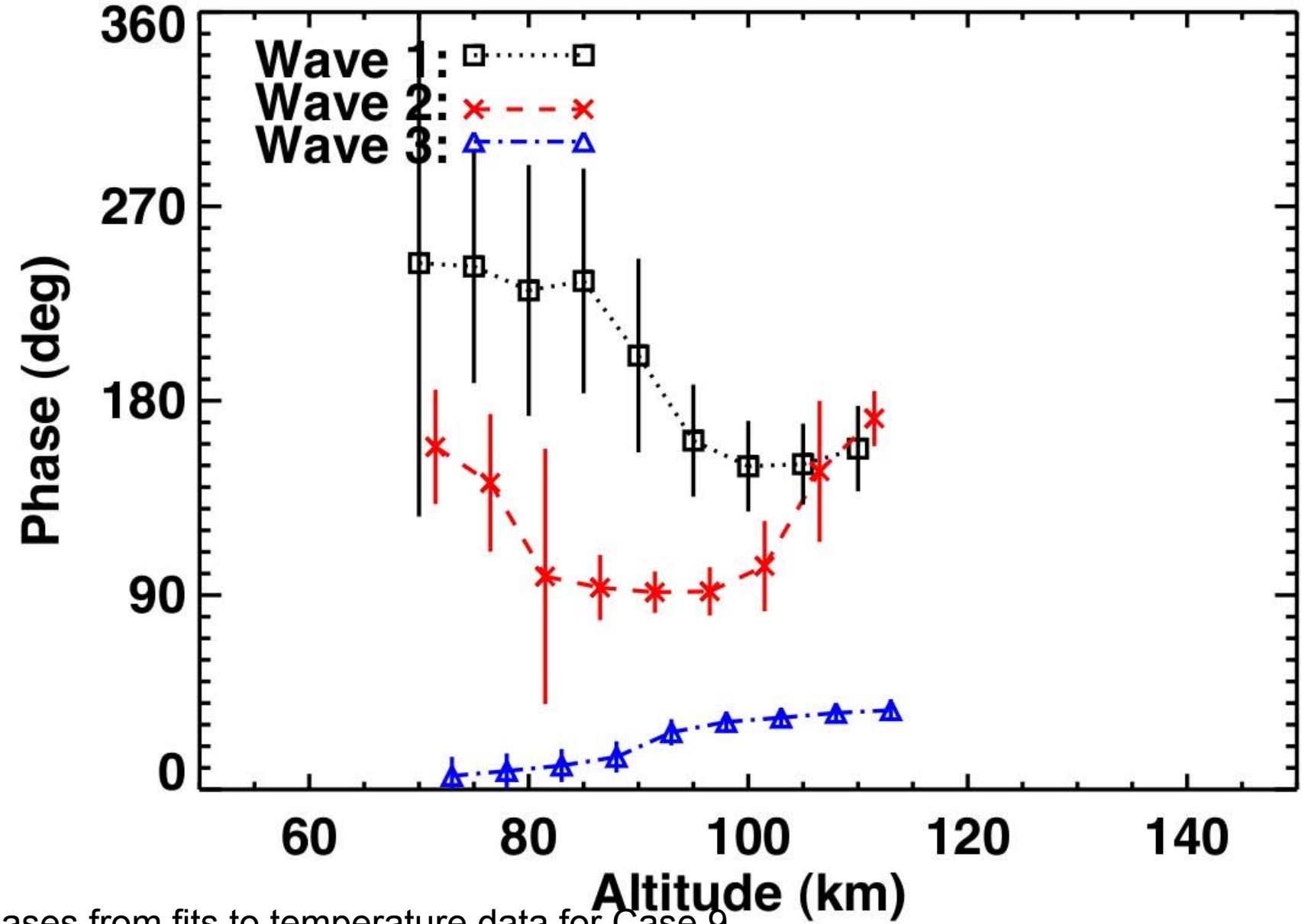
Theoretical relationship between variations in pressure and temperature



Pressure at 100 km for Case 9



Temperature at 100 km for Case 9
Zonal structure is apparent in temperature data
Wave 1 and 2 components of pressure and temperature data have similar phases

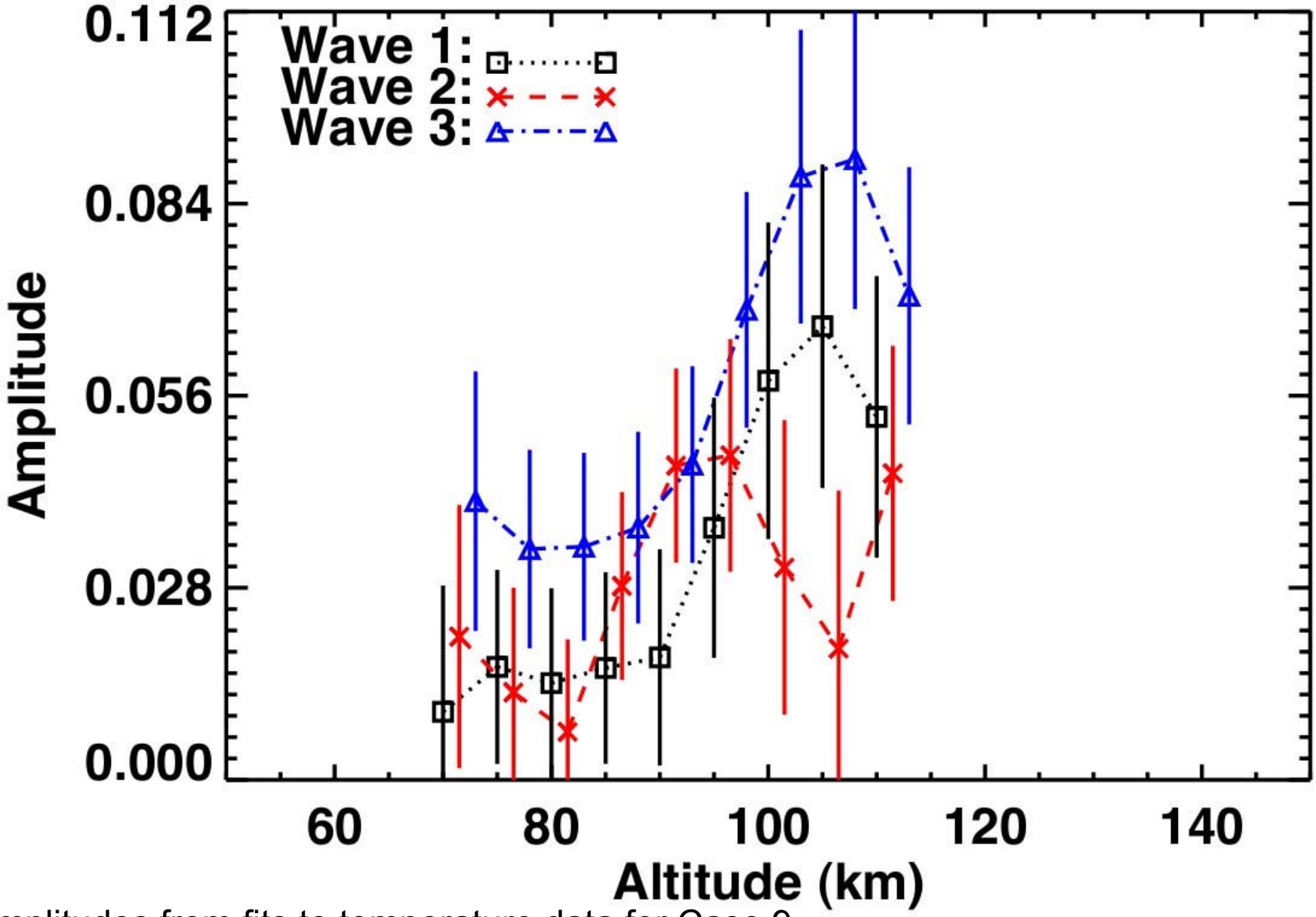


Phases from fits to temperature data for Case 9

Much more variable than pressure phases

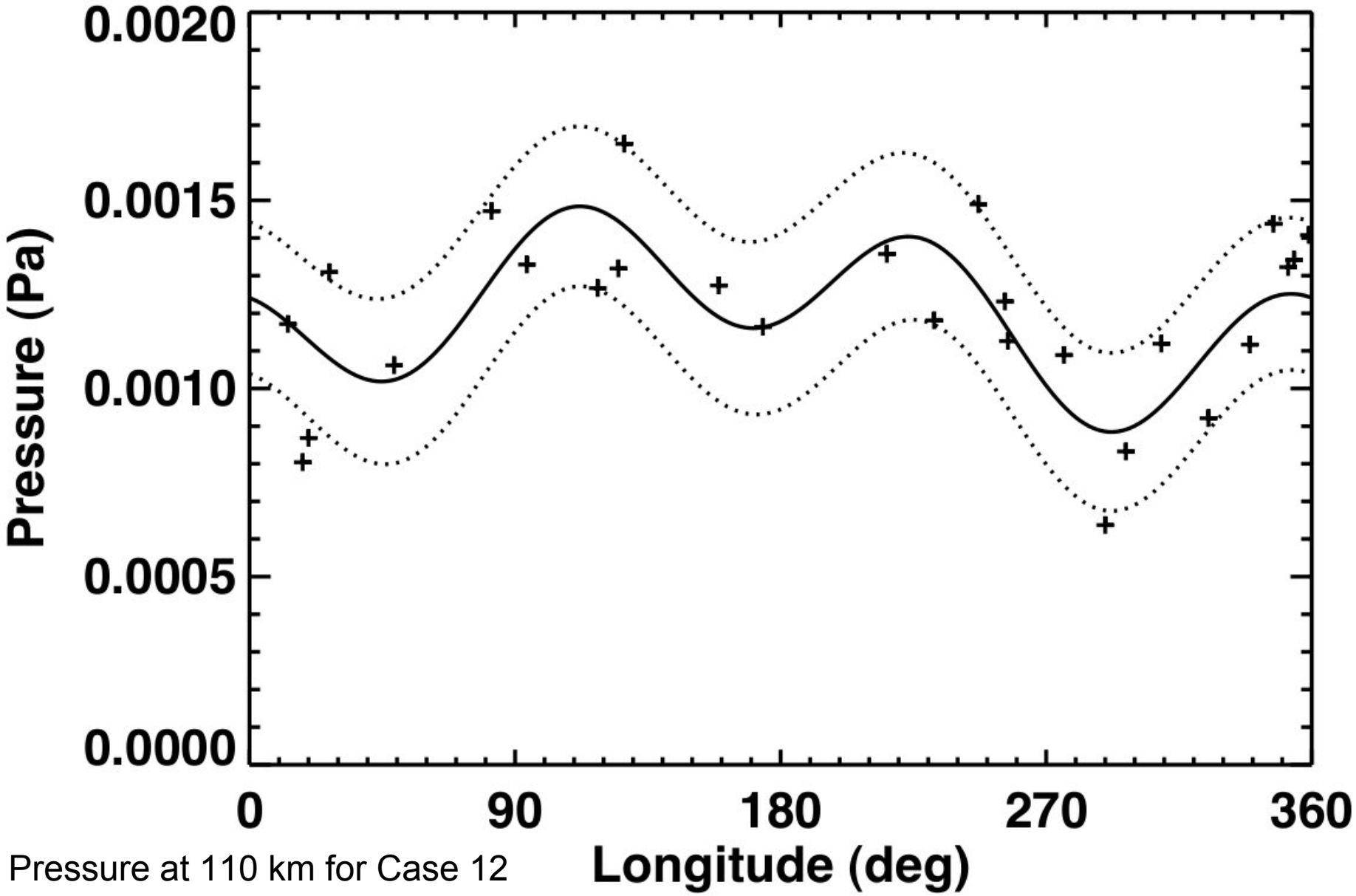
Wave 2 phase in p and T is same at 100 km, where p amplitude is increasing fastest

Wave 3 phase in p and T is same at 80 km, where p amplitude is increasing



Amplitudes from fits to temperature data for Case 9

Not great agreement with predicted amplitudes here, better examples in Cases 2 and 10



Pressure at 110 km for Case 12

Amplitude of Wave 2 component is 0.013 +/- 0.047, typical amplitude is 0.3

Why is Wave 2 component (DK1) vanished at 40S-30S, Ls=150-180, LST=22-24 hrs?

Discussion

- Zonal variations due to thermal tides are present in SPICAM pressure and temperature profiles
- Phases of pressure components are stable between 70 km and 110 km
- Changes in amplitude of pressure components with altitude constrain dissipative processes
- Theory can relate zonal temperature variations to how zonal pressure variations change with altitude
- DK1 (usually dominant) is absent from one unusual case