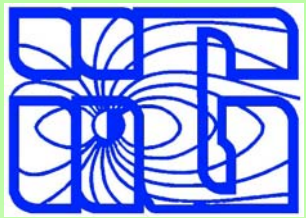
Mesopause Temperatures from the Observation of OH (6 – 2) Meinel Band Emissions at Kolhapur, India



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Outline of Talk

- Introduction
- Experimental Set Up
- Results & Discussions
- Conclusions

Introduction

- ***Airglow*** *– emission of photons*
- ***OH*** *emissions*
  - **Ro-vibrational** transitions within **OH** ($X^2\Pi$).
  - Wavelength spread ~ 4 000 – 40 000 **Å**.
  - Integrated nightglow intensity ~ 5 M**R**.
  - Emission Peak ~ 87 ± 4 km.
- ***Mesopause***

The region of temperature minimum between stratosphere and lower thermosphere.

Mesopause temperatures from **OH** emissions

Measuring intensity distribution between various lines or branches within a band

"OH molecules producing the emission are energetically indistinguishable from the surrounding atmosphere"

Why study Mesopause temperature?

- Coldest part of terrestrial atmosphere.
- Investigation of Gravity waves & Tides.
- Chemical reactions are functions of ambient temperature.
- Phenomenology of noctilucent clouds & polar mesospheric echoes.

OH* Production & OH Airglow

Primary Source is **Ozone-hydrogen reaction** –

Largest contributor to chemical heating

$$O_3 + H \rightarrow OH + O_2 + 3.34\ eV$$

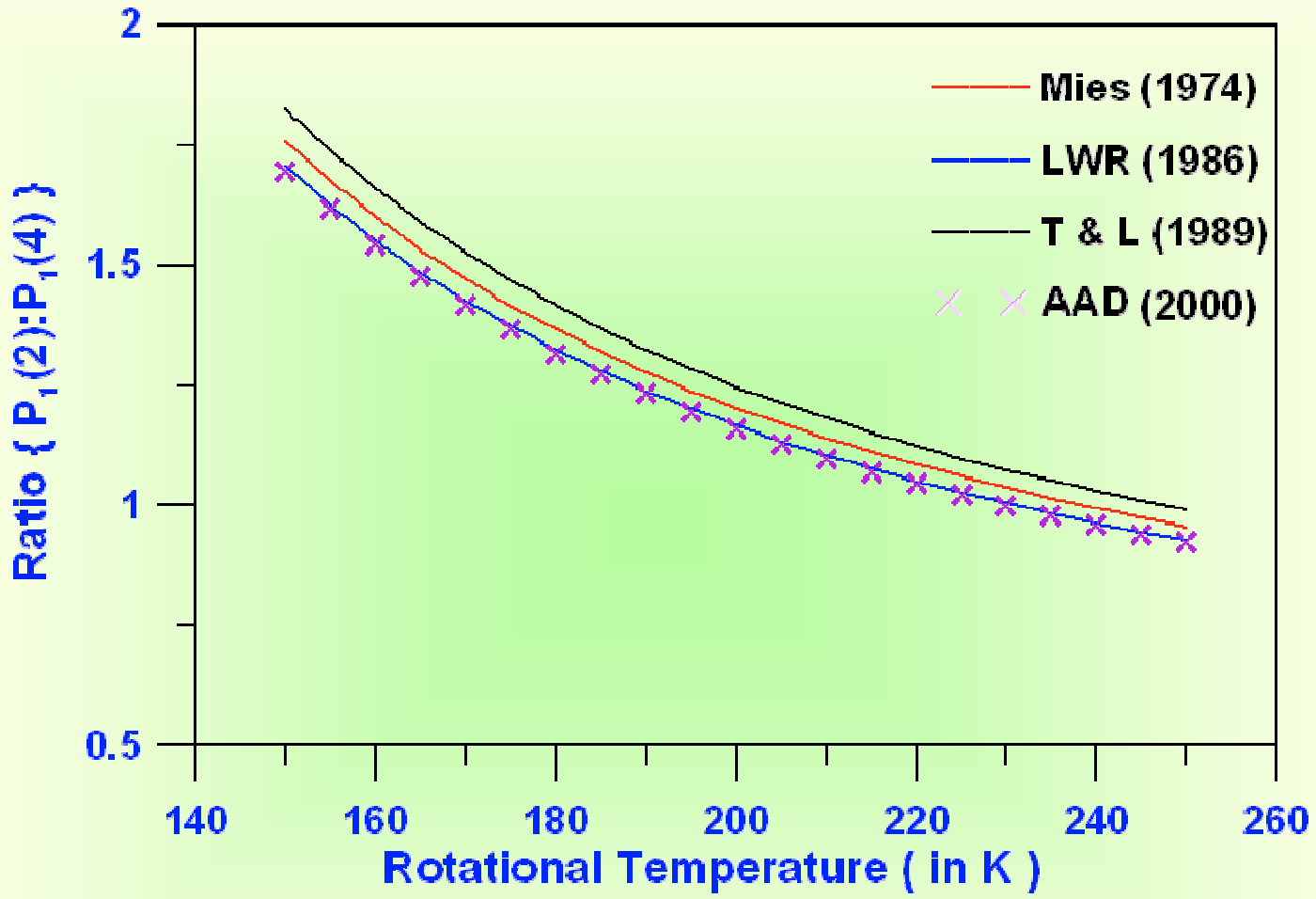
OH (6 – 2) Airglow & Rotational Temperature

60 % of released as heat

Rest radiated as OH airglow

- Rotational transitions from $\upsilon = 6$ to $\upsilon = 2$.
- Band origin – 11980.50 cm $^{-1}$ (834.46 nm).
- Integrated band intensity ~ 1.7 K**R**.
- Collisions suffered before de-excitation ~ 180.
  - Sufficient for thermalization of OH* in $\upsilon = 6$ level.
  - Rotational temperature represents Mesopause temperature.
- Rotational temperatures are derived from ratio of $P_1(2)$ to $P_1(4)$ line intensity.

Ratio Vs Rotational Temperature Curve



Term values: Kendall & Clark (1979)

Transition Probabilities:Mies = Mies, F. H. (1979); LWR = Langhoff et al. (1986);
T & L = Turnbull & Lowe (1989); AAD = French et al. (2000)

Experimental Set Up

Observation Site:

Kolhapur (16.8°N, 74.2°E, Dip lat. – 10.6° N**)**

Instrument Deployed:

All Sky Scanning Photometer

FoV = 7.24°, Photomultiplier Used - GaAs

Temporal Resolution – 10 to 60 minute

Scan mode – North-South Scan

Data used – December 2004 to May 2005.

Lines & Filters:

P_1 (2) Line – 839.92 nm (λ_C= 840 nm, bw = 0.8 nm)

P_1 (4) Line – 846.54 nm (λ_C= 846.6 nm, bw = 1.2 nm)

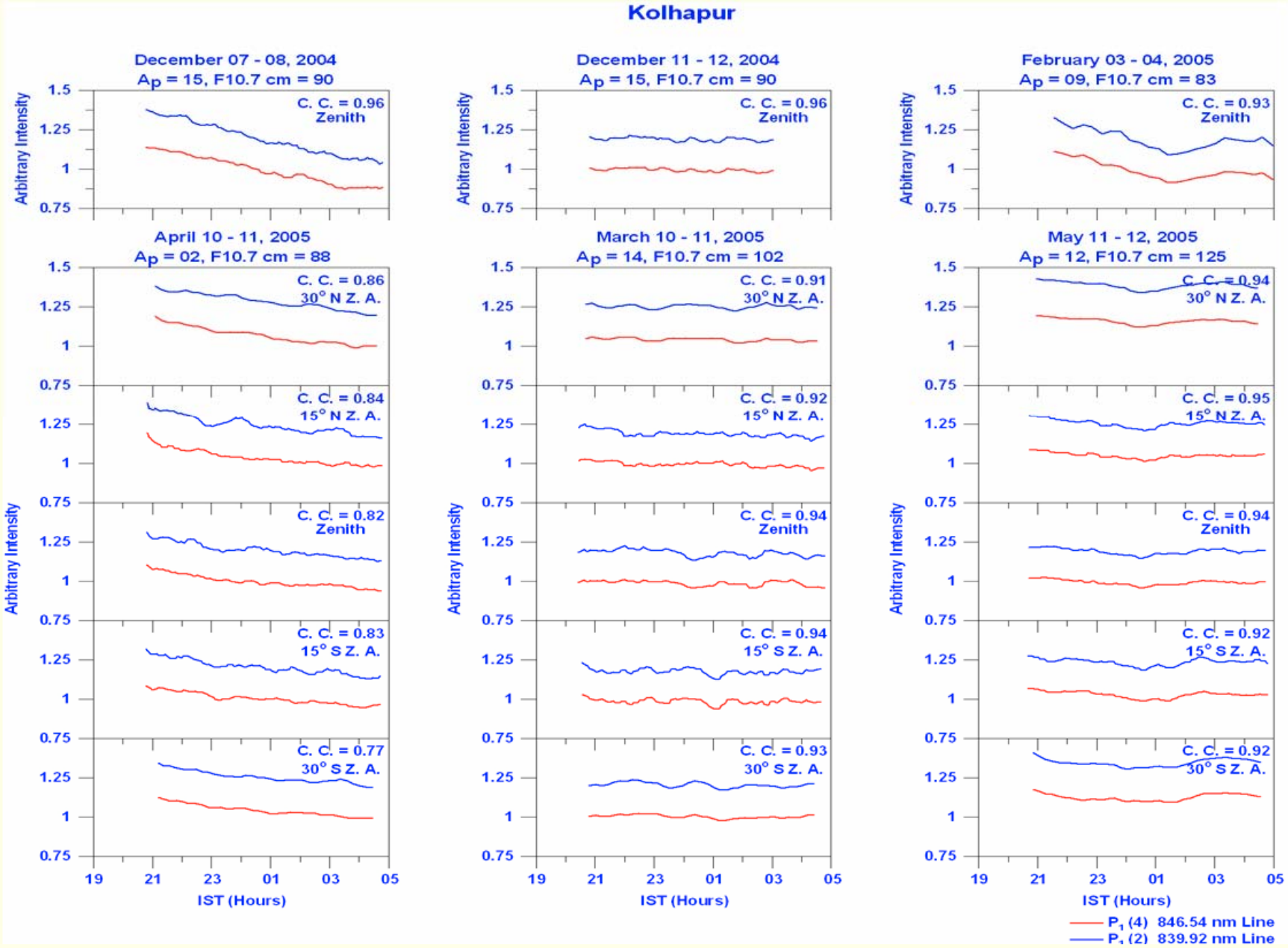
Background Filter - (λ_C= 857.2 nm, bw = 1 nm)

Results & Dicussions

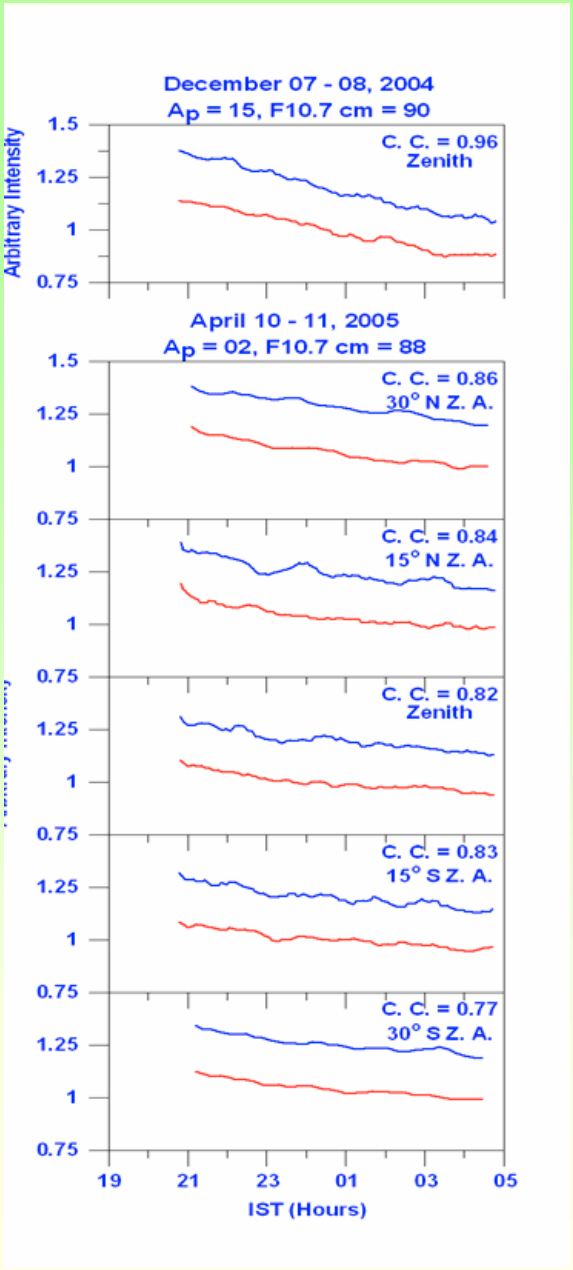
Correlation amongst $P_1(2)$ & $P_1(4)$ emissions

Angle w. r. t. zenith	Percentage of nights having correlation coefficient ≥ 0.85	Minimum value of correlation coefficient
30° N	100	0.86
15° N	88	0.77
0°	90	0.82
15° S	94	0.83
30° S	94	0.77

Temporal Intensity Variations



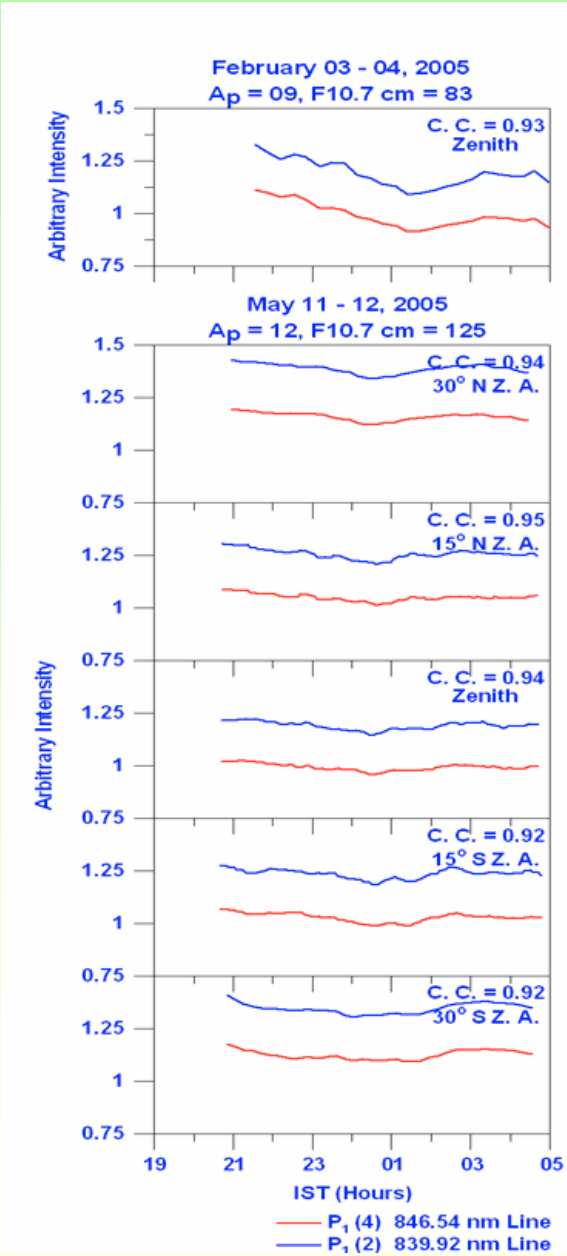
Temporal Intensity Variations



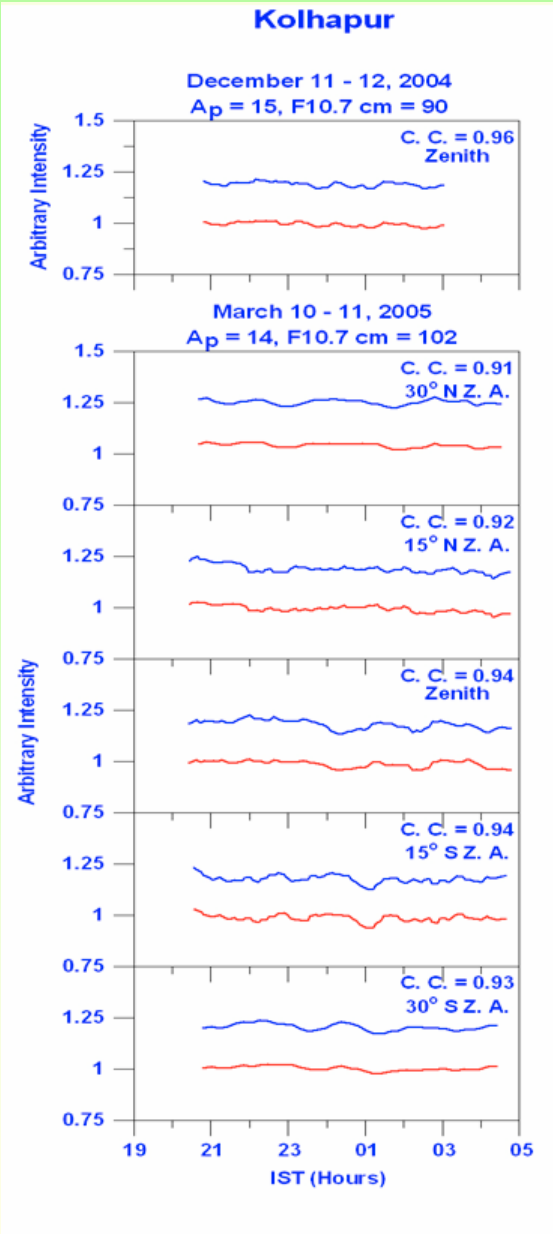
- Decreasing Intensity
  (decreasing H & O concentration)
- Present in 48 % of nights.

Temporal Intensity Variations

- Midnight minimum
  (Tidal wave energy input)
- Present in 19 % of nights.



Temporal Intensity Variations



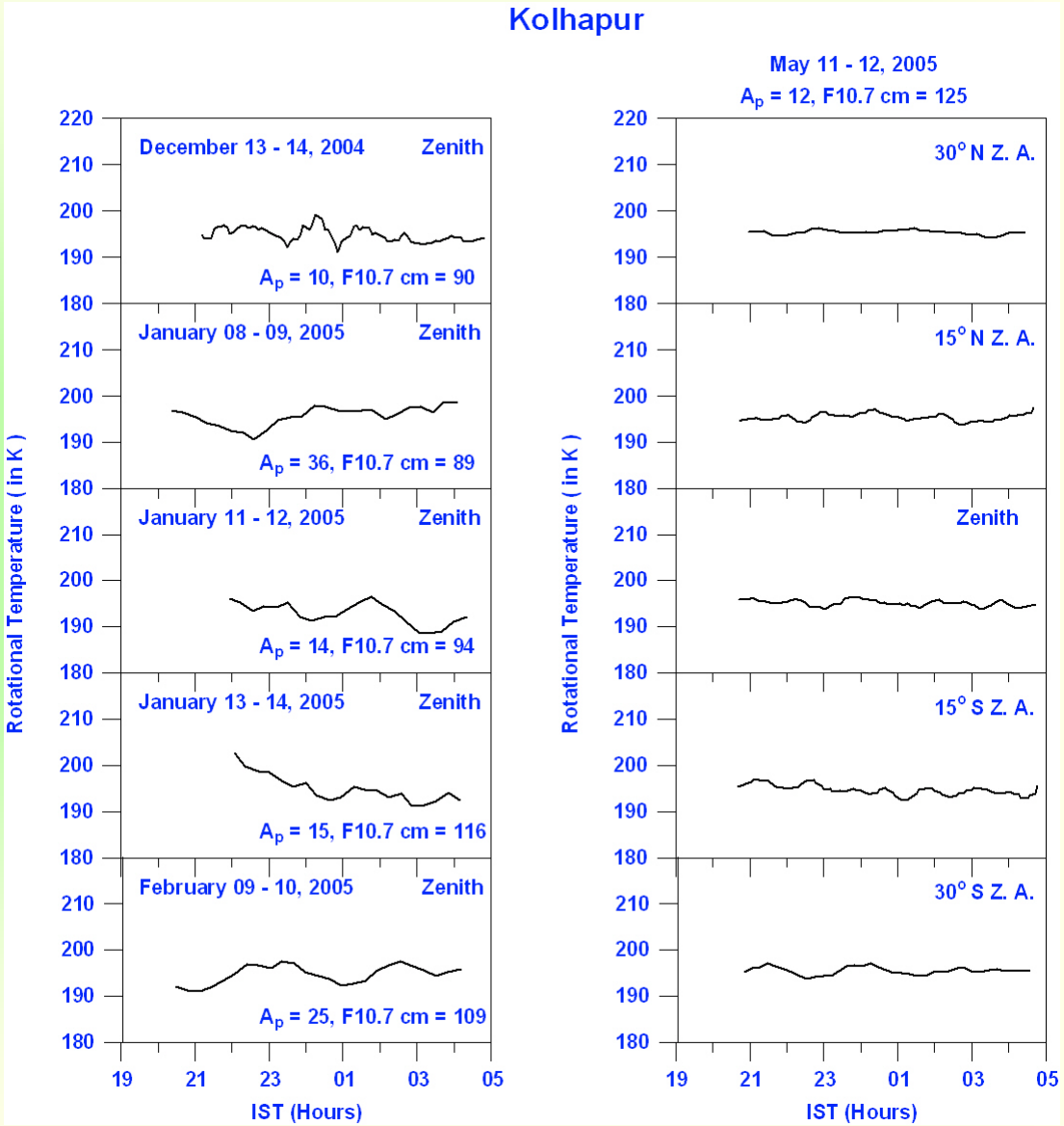
Around 32 % of nights

Temporal Intensity Variations

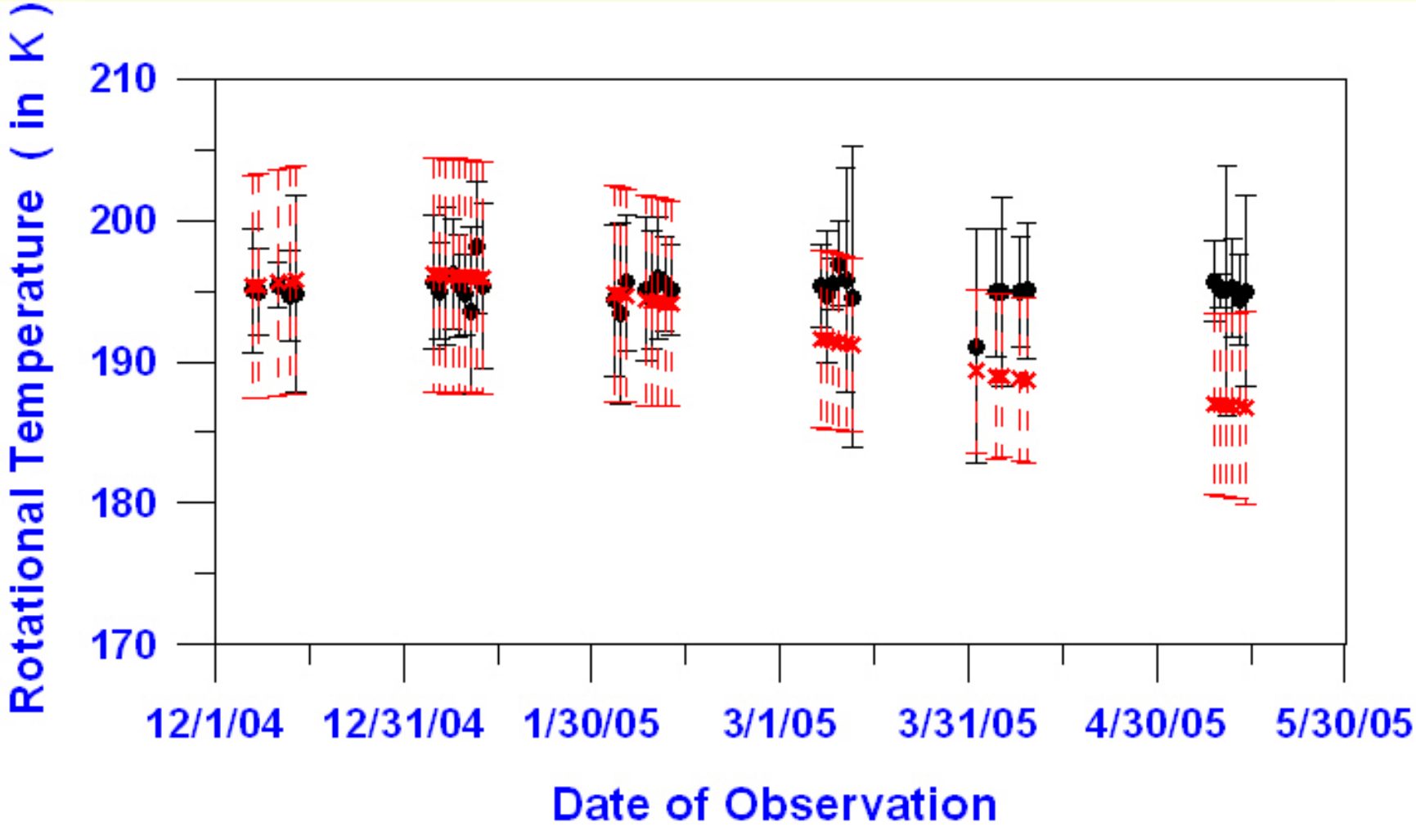
- Small wave-like variations superimposed over long term variations were also observed.

Temporal Temperature Variations

- Wide variety of trends
  - Increasing trend
  - Decreasing trend
  - Constant trend
  - Wave-like variations



Comparison with MSISE 90 Model



- ● Mean nightly derived temperature
- × Mean nightly MSISE 90 predicted temperature

Average Temperature (in K) along Zenith and ± 15º & ± 30º Off-zenith directions

Direction	LWR	Mies	L & T	AAD
30º N Z. A.	195 ± 5	201 ± 5	207 ± 5	194 ± 5
15º N Z. A.	195 ± 5	200 ± 5	207 ± 5	194 ± 5
Zenith	195 ± 5	200 ± 5	207 ± 5	194 ± 5
15º S Z. A.	195 ± 5	200 ± 5	207 ± 6	194 ± 5
30º N S. A.	195 ± 5	200 ± 5	207 ± 5	194 ± 5

Dependence on Choice of Transition Probabilities

- **AAD values** are the lowest one.
- **LWR values** are **1 K higher** than **AAD values**.
- **Mies values** are **5 K higher** than **AAD values**.
- **T & L values** are **13 K higher** than **AAD values**.

Conclusions

- **High Degree of Correlation** is observed amongst $P_1(2)$ & $P_1(4)$ line emissions of OH (6 – 2) band.
- **Wave-like variations** are observed in temporal variation of both intensity & temperature.
- **No significant diurnal & seasonal variation** is observed in mean nightly variation of both intensity & derived temperature.
- **Derived temperatures** are in **good agreement** with **MSISE 90 predicted values**.
- **Poor correlation of temperature** with **Ap** & **F 10.7 cm flux** is observed.
- **Average temperature of mesopause at Kolhapur** is **195 ± 5 K** (using Langhoff et al., 1986 transition probabilities).

Thank You