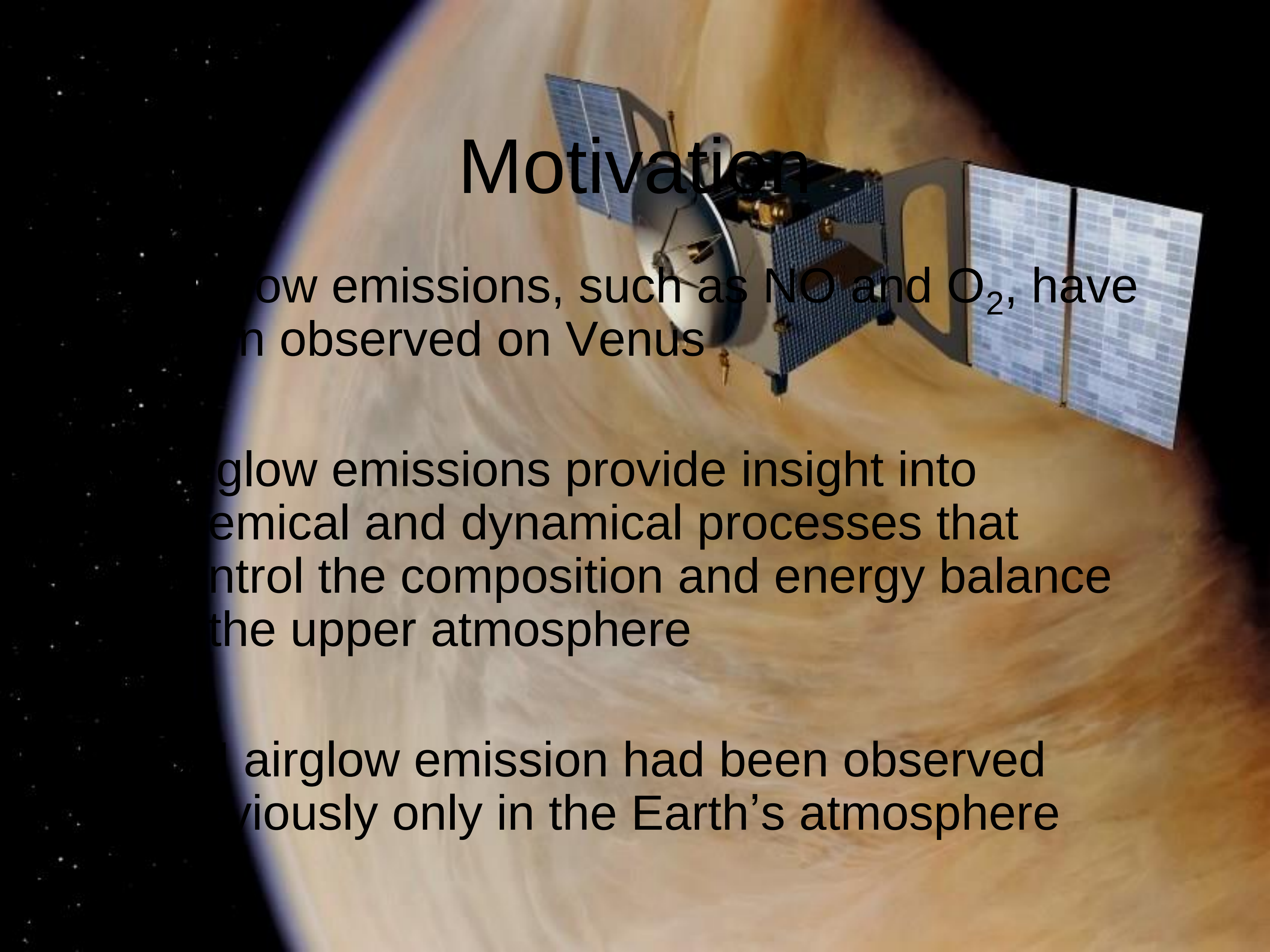
Modeling of Observations of the OH Nightglow in the Venusian Mesosphere

C. D. Parkinson

S. W. Bougher, F. Mills, Y. L. Yung, A. Brecht

International Venus Conference,

June 3, 2019

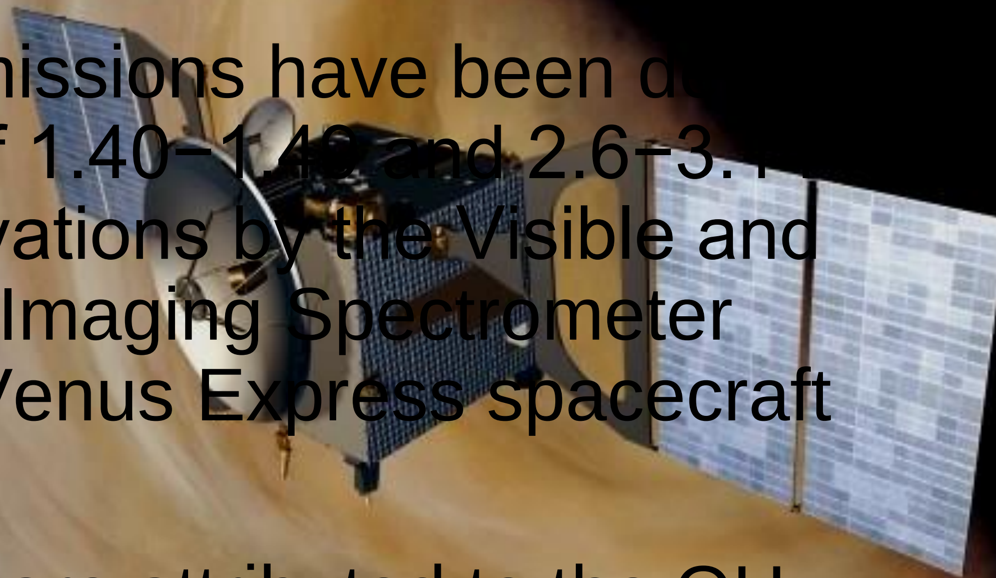


Motivation

- ow emissions, such as NO and O_2, have
n observed on Venus
- glow emissions provide insight into
emical and dynamical processes that
ntrol the composition and energy balance
the upper atmosphere
- airglow emission had been observed
viously only in the Earth’s atmosphere

NS:

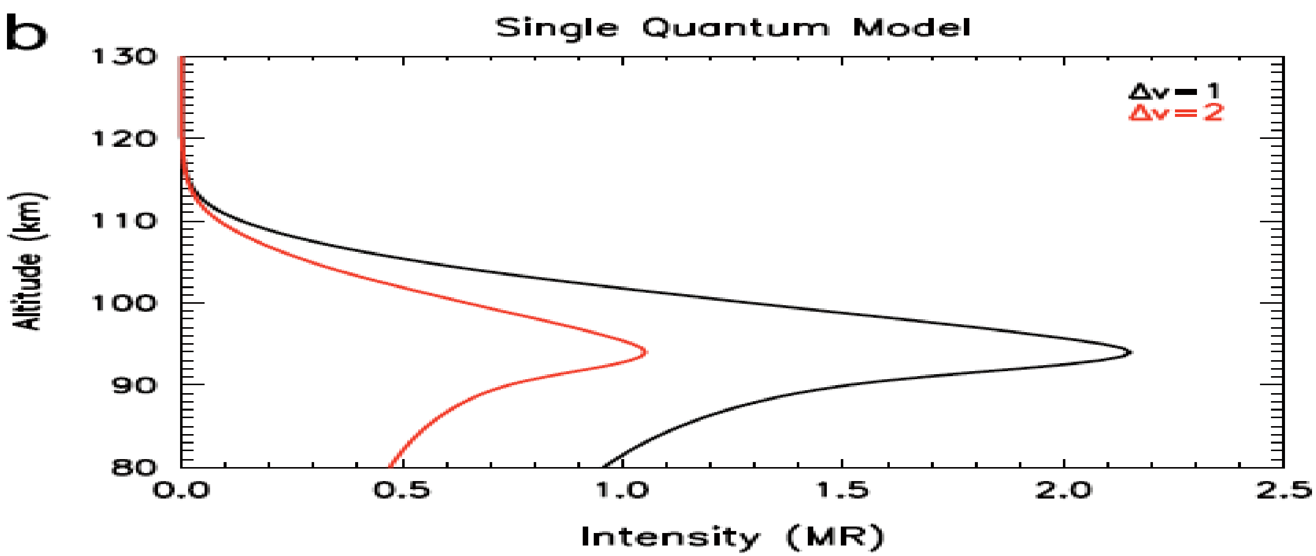
irglow emissions have been d
elengths of 1.40−1.49 and 2.6−3.
limb observations by the Visible and
red Thermal Imaging Spectrometer
RTIS) on the Venus Express spacecraft



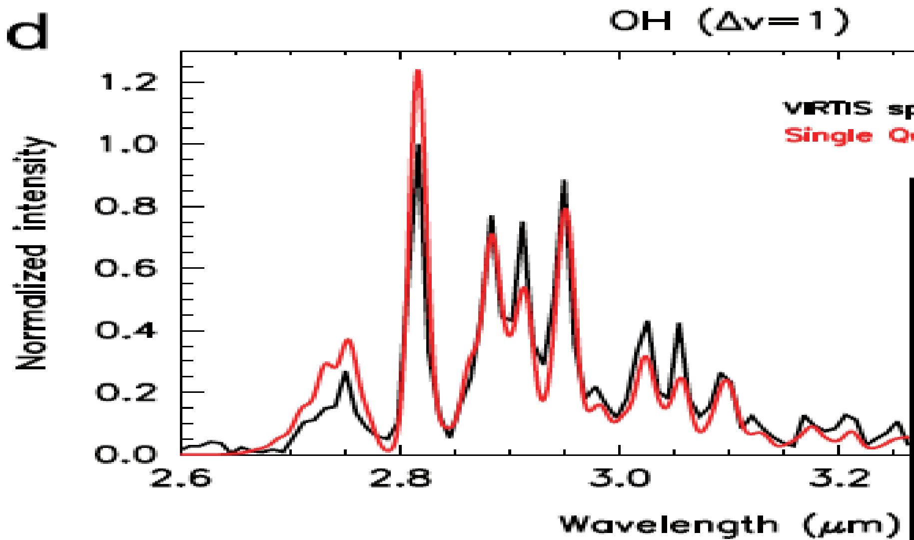
ese emissions are attributed to the OH
−0) and (1−0) Meinel band transitions
iccioni et al., 2008).

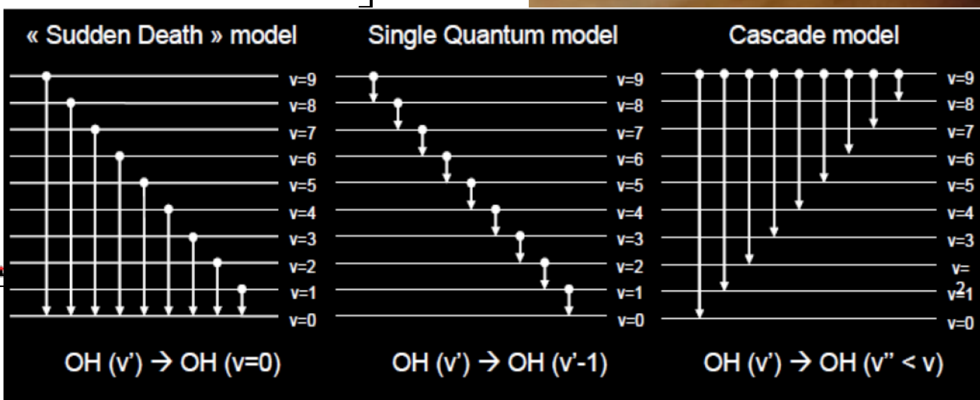
e integrated emission rates for the OH
0) and (1−0) bands were measured to be
±40 and 880±90 kR respectively, both
king at an altitude of 96±2 km near
ight local time for the considered orbit.

IS OH Airglow Obse
et al. (2012) updated ana



To fit observations, they must use single quantum cascade model with weighted coefficients for each transition and temperature of 180^{o}K





Tale of Two Models

st of talk devoted to discussion of
orts used to model VIRTIS
bservations just discussed using

1-D Caltech/JPL model

Michigan VTGCM model

ng: Key Reactions fo

Channel	Reaction	Rate Coefficient	Reference	Heat of Reaction
(1)	$H + O_3 \rightarrow OH(v) + O_2$	1.40e-10*exp(-470/ T)	Sander et al 2002	27000 cm^{-1}
(2)	$HO_2 + O \rightarrow OH(v) + O_2$	3.00e-11*exp(200.0/T)	Sander et al 2002	19000 cm^{-1}
(3)	$Cl + HO_2 \rightarrow ClO + OH$	4.10E-11 EXP(-450/T)	Sander et al 2002	-500 cm^{-1}
(4)	$SO + HO_2 \rightarrow SO_2 + OH$	2.80E-11	Yung and DeMore 1982	23000 cm^{-1}

thermicities of these nnel (2) has the ite OH(v) levels up to (1) up to levels v=6.

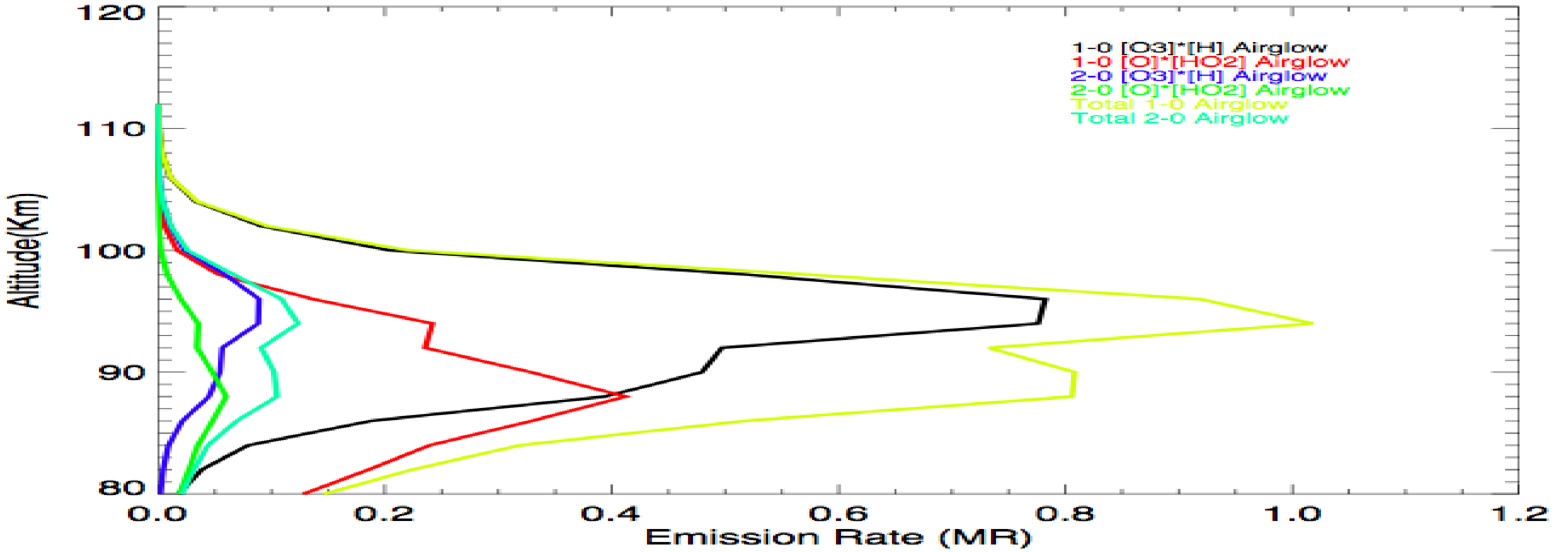
Due to exothermicity arguments, channel (3) does NOT contribute to OH(v)

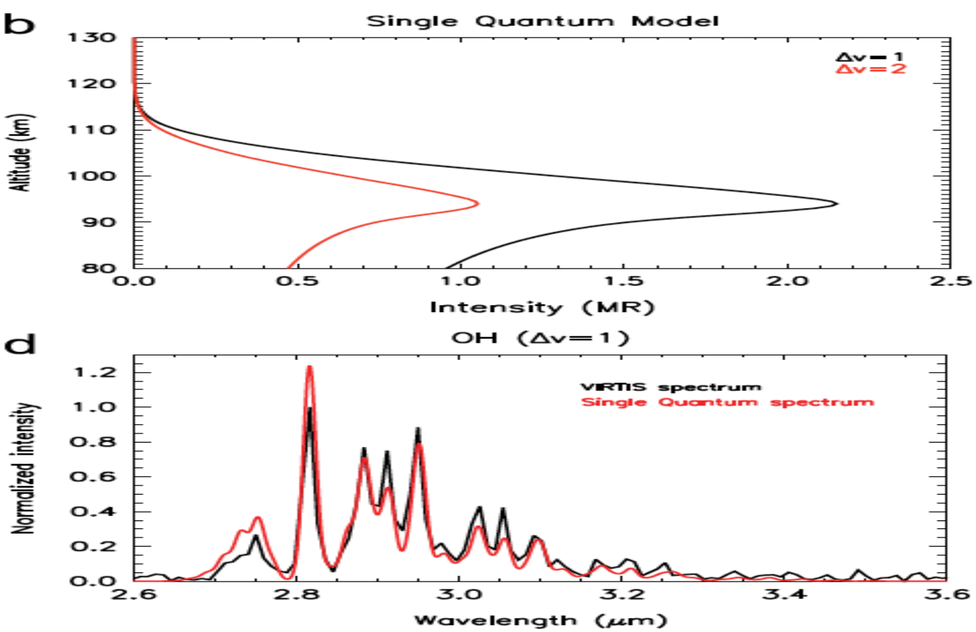
We are investigating channel (4)

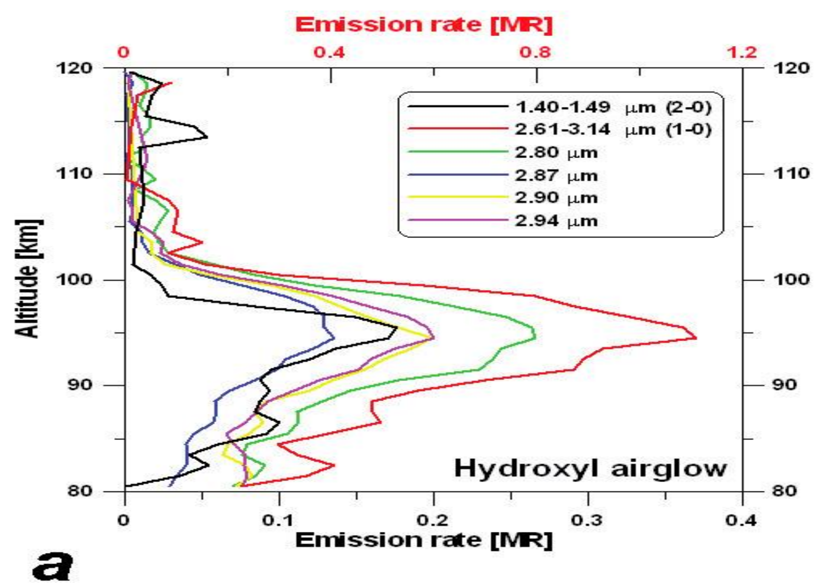
nt distributions of
ed via channels (1) and

Reaction	v	f_v (Adler-Golden, 1997) **Caltech/JPL 1-D Kinetics Model**	f_v (García Muñoz et al., 2005)	f_v (Krasnopolsky, 2010)
(1)	9	0.47	0.35	
(1)	8	0.34	0.29	
(1)	7	0.15	0.19	
(1)	6	0.03	0.07	
(1)	5	0.01	0.05	
(1)	4	0	0.05	
(1)	≤ 3	0	0	
(2)	6	0.47		0
(2)	5	0.34		0
(2)	4	0.15		0
(2)	3	0.03		0.3
(2)	2	0.01		0.3
(2)	1	0		0.3
(2)	0	0		0.1

1-D modeled and normalized OH Airglow







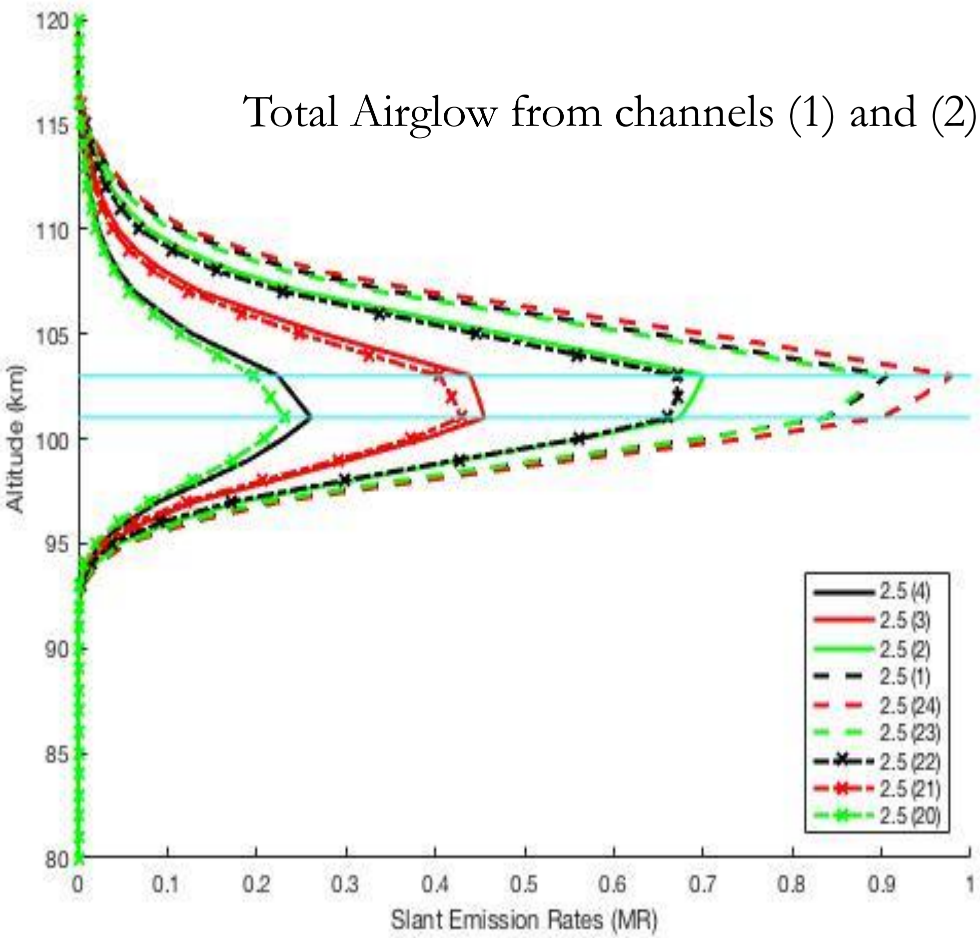
GCM modeling results

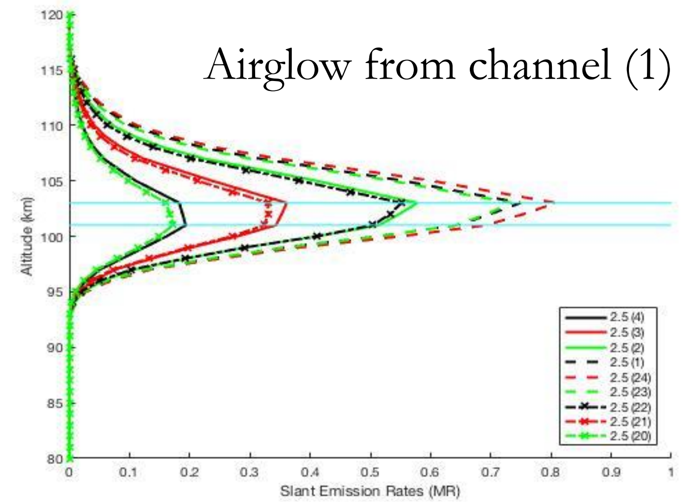
vantages:

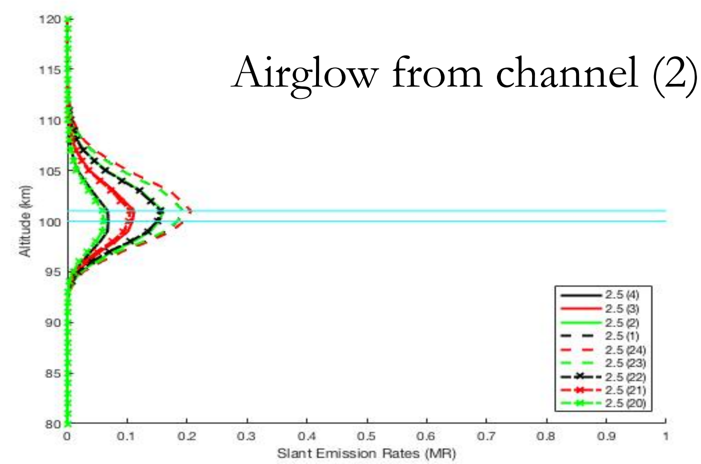
- Heating and cooling terms included
- Allows for variable temperature profile
- Adds latitudinal and longitudinal variation in umber density (and hence airglow) of OH brational species

l Airglow, varying l

band system slant path emissi[...] corresponding
ofiles for 2.5 N LAT (LT = midnight +/- 1, +/-2, +/-3, +/-4)
iation consistent with the O_2 airglow

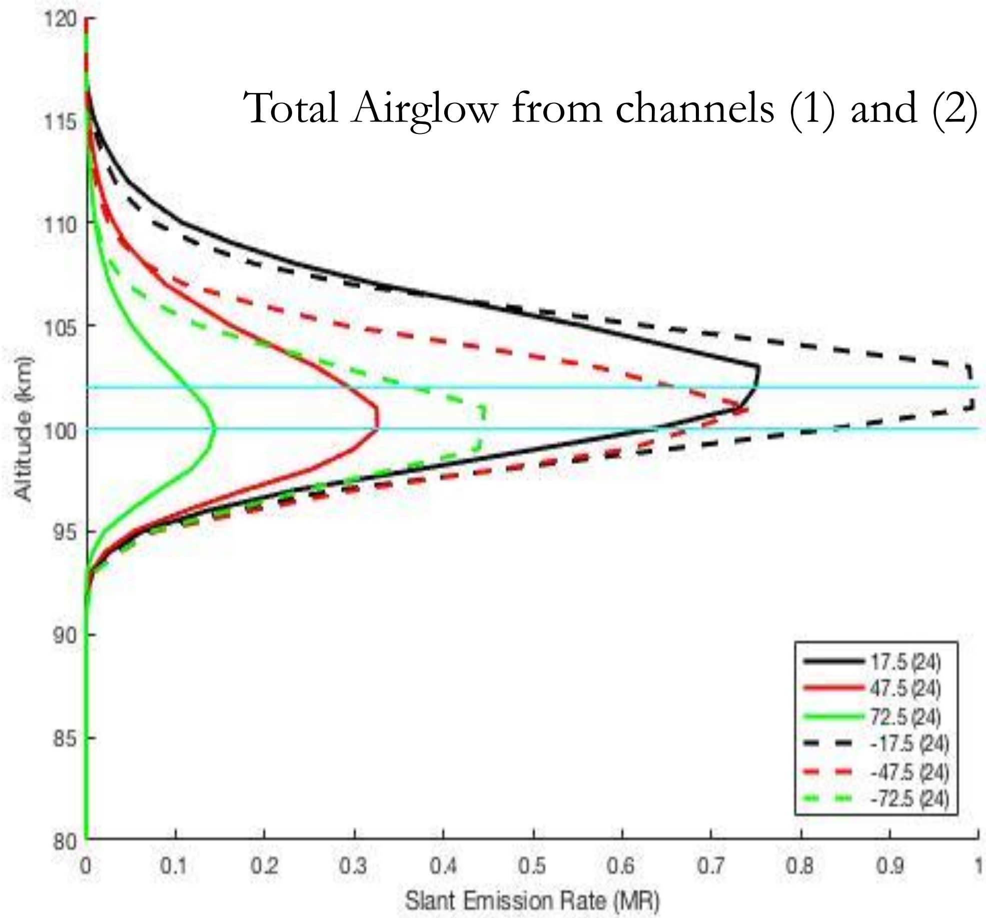


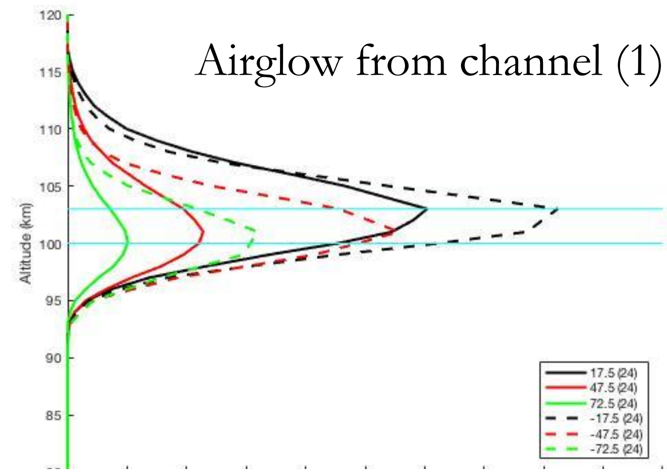


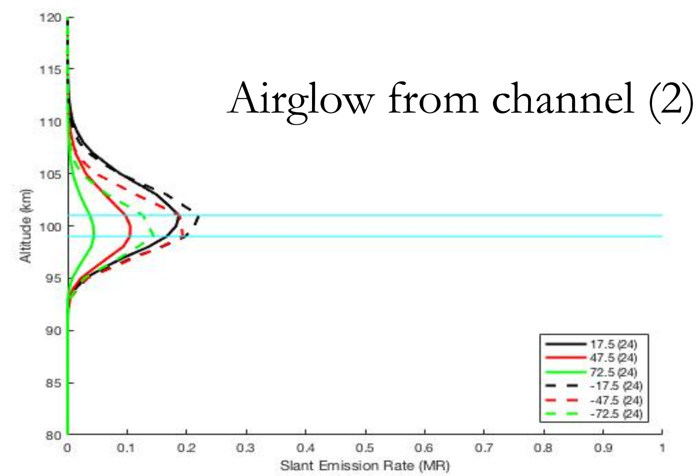


t Airglow, varying la

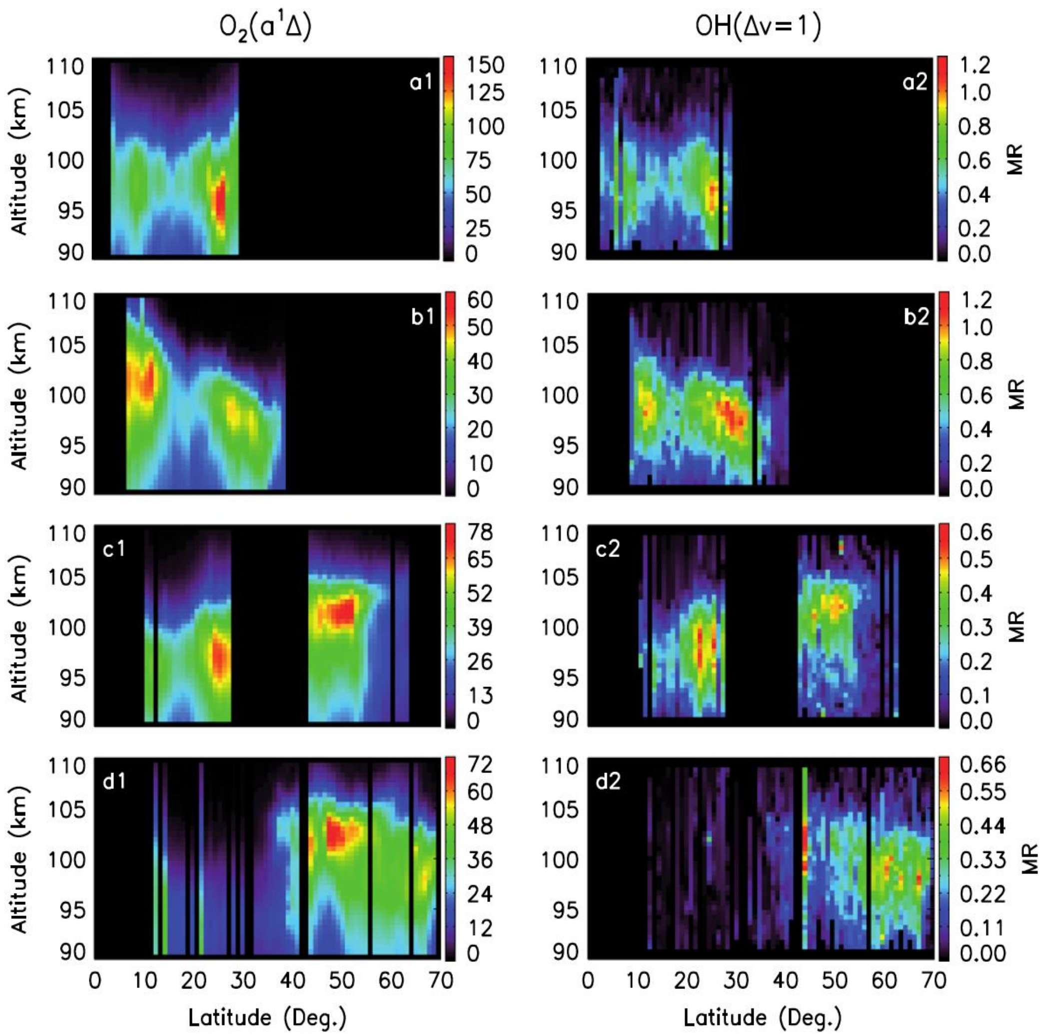
stem slant path emission rates corresponding to p
T = 2.5N, 17.5N, 47.5N, 72.5 N, 17.5S, 47.5S, 72.5 S)
ic asymmetries due to the lower boundary specified … we
uantify a little better to understand it.

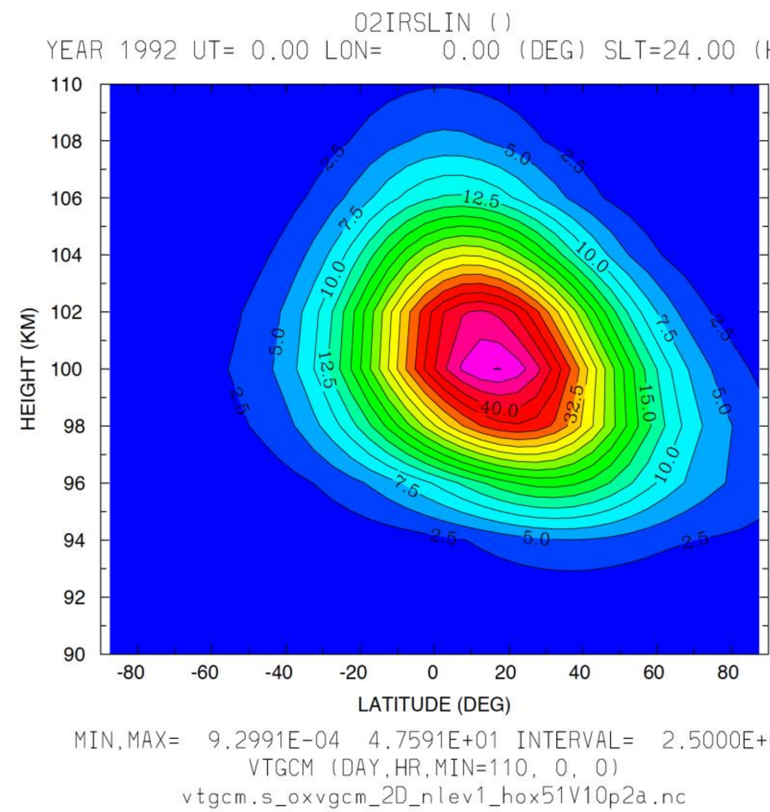




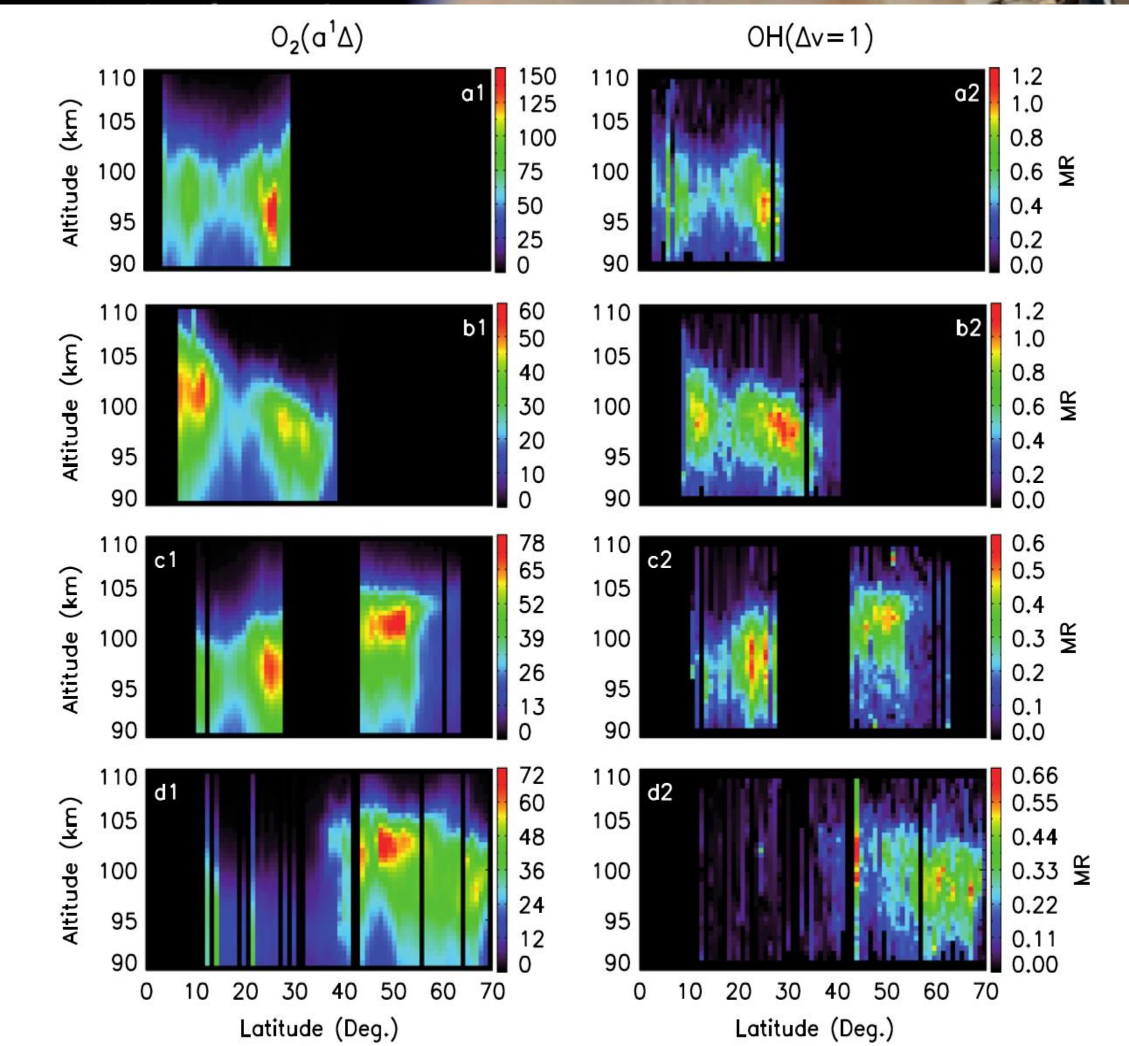


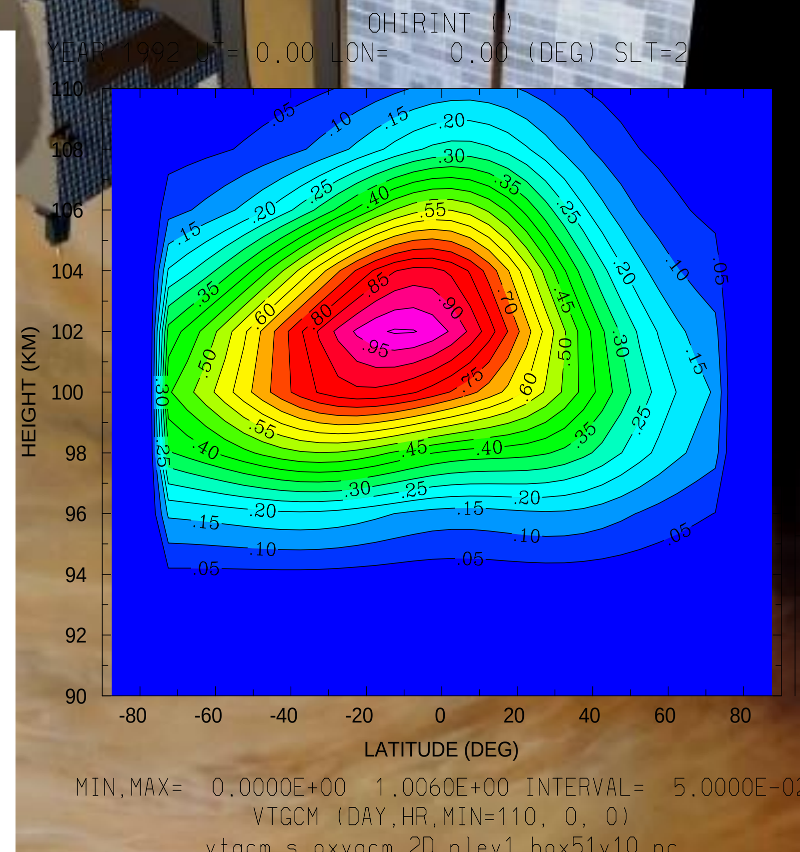
...ant emission (along the ... (MegaRayleighs) 90 to 11... pole to pole) at LT = 24 (2-D)



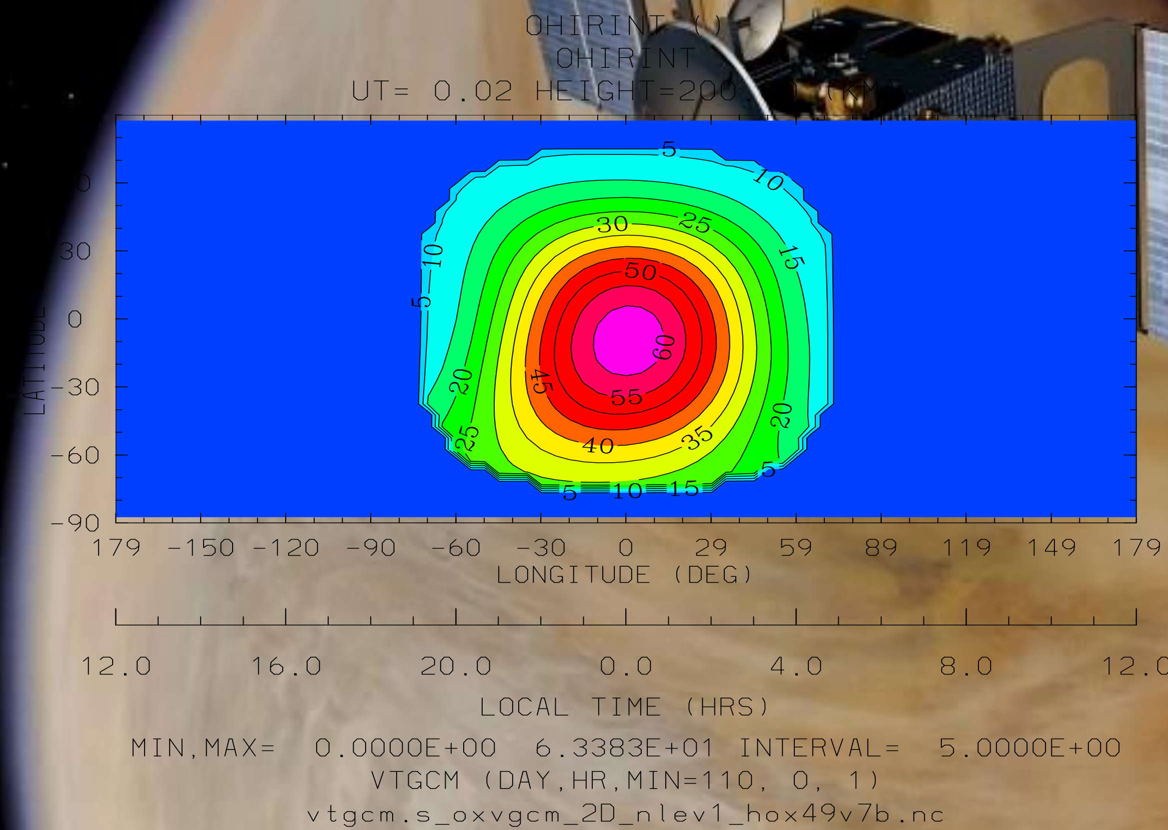


ant emission (along th
(MegaRayleighs) 90 to 11
pole to pole) at LT = 24 (2-D)





d Intensity: Both C



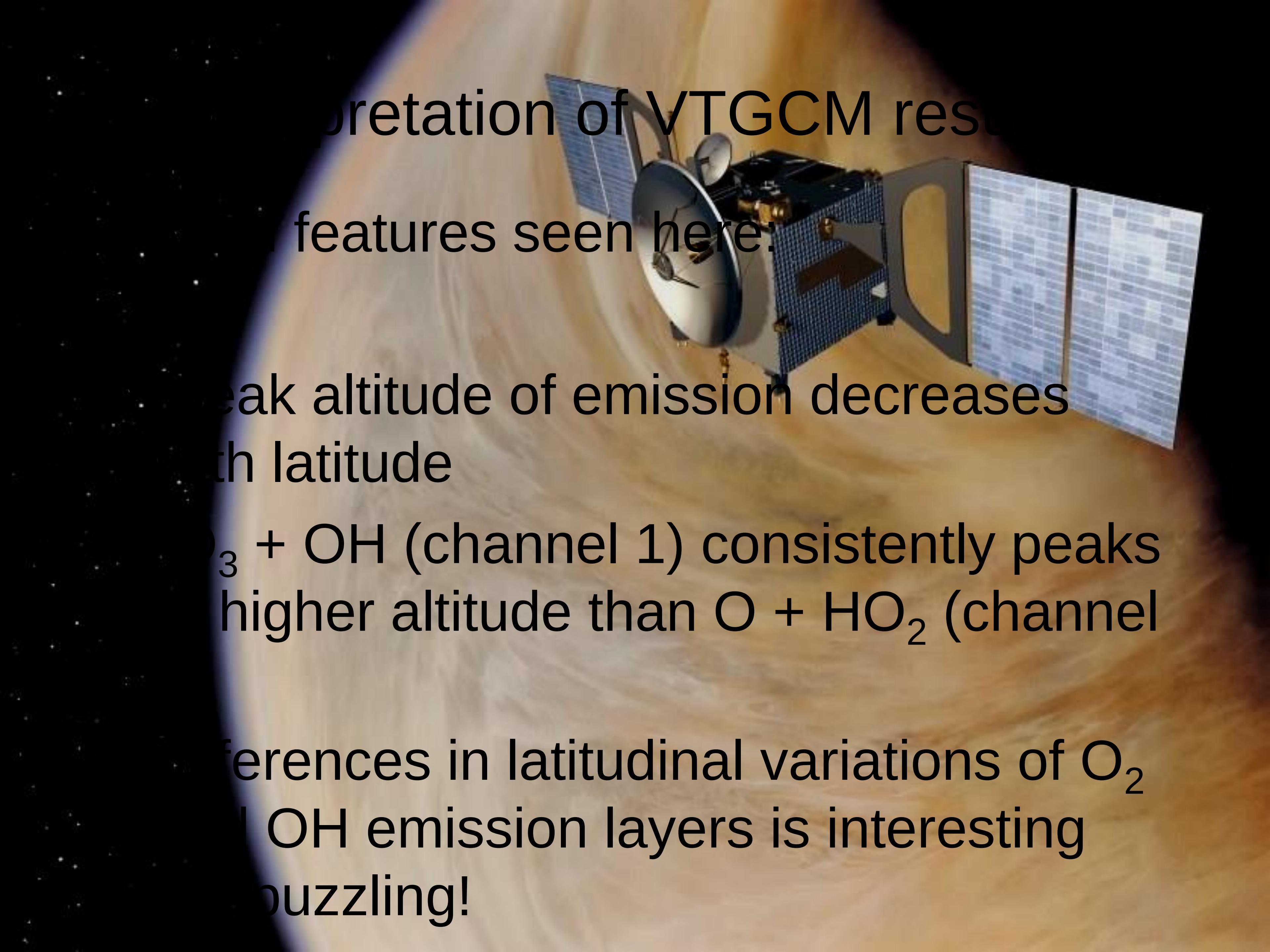
Integrated vertical intensity (kR units)

that the integrated vertical intensity shows
ear midnight and just South of the equator

etation of VTGCM res

udinal differences are clearly seen
tween the N. hemisphere and S.
misphere

he magnitude of this emission (both
tegrated slant path intensity and
lume emission rate) are consistent
h VEx VIRTIS slant path
servations



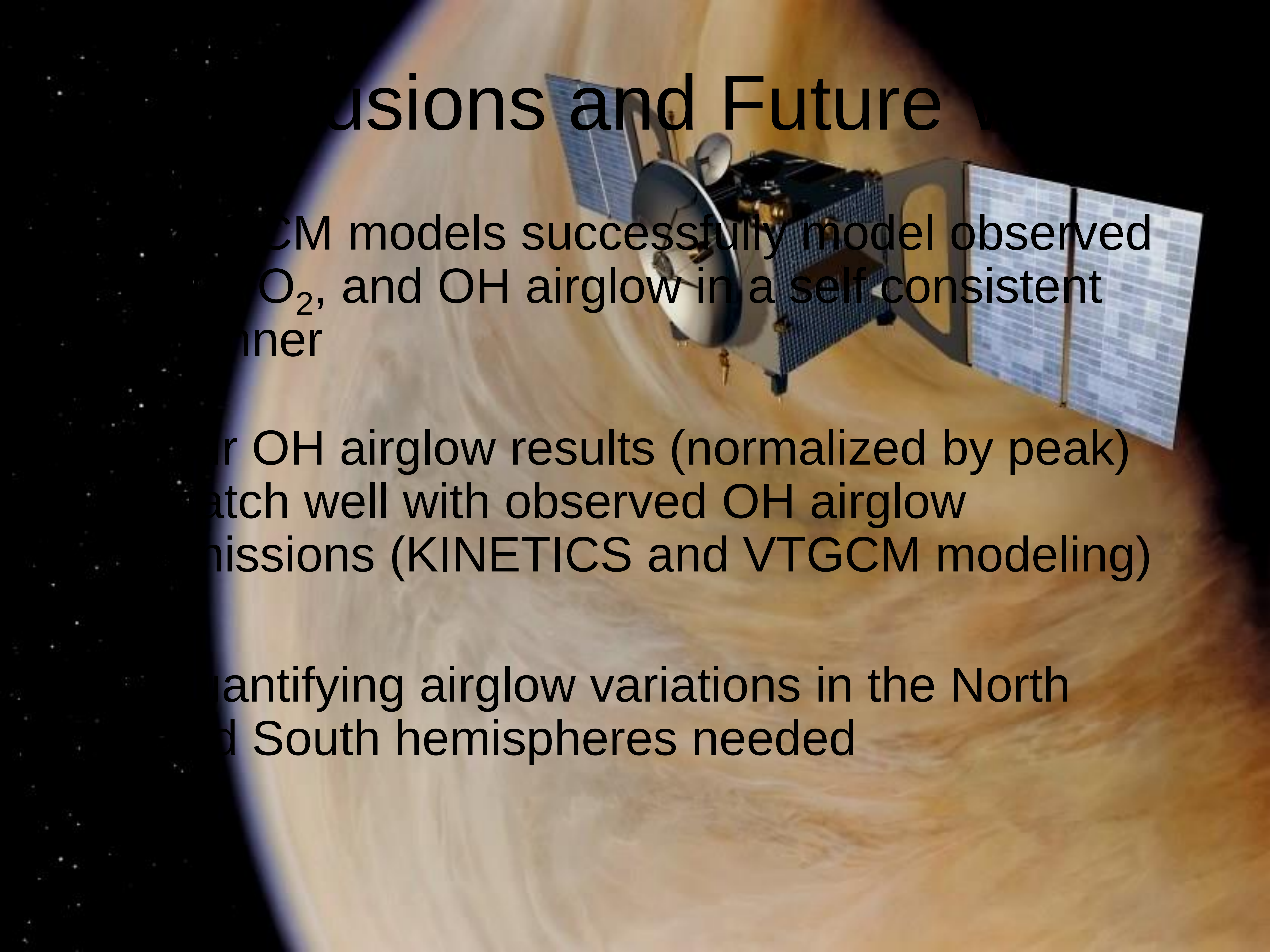
pretation of VTGCM res

features seen here:

eak altitude of emission decreases
th latitude

$_3$ + OH (channel 1) consistently peaks
higher altitude than O + HO_2 (channel

ferences in latitudinal variations of O_2
OH emission layers is interesting
puzzling!



usions and Future

CM models successfully model observed
O_2, and OH airglow in a self consistent
nner

r OH airglow results (normalized by peak)
atch well with observed OH airglow
nissions (KINETICS and VTGCM modeling)

uantifying airglow variations in the North
d South hemispheres needed