The Composition of Saturn's Storm Clouds: The Great Storm of 2010-2011 and Beyond

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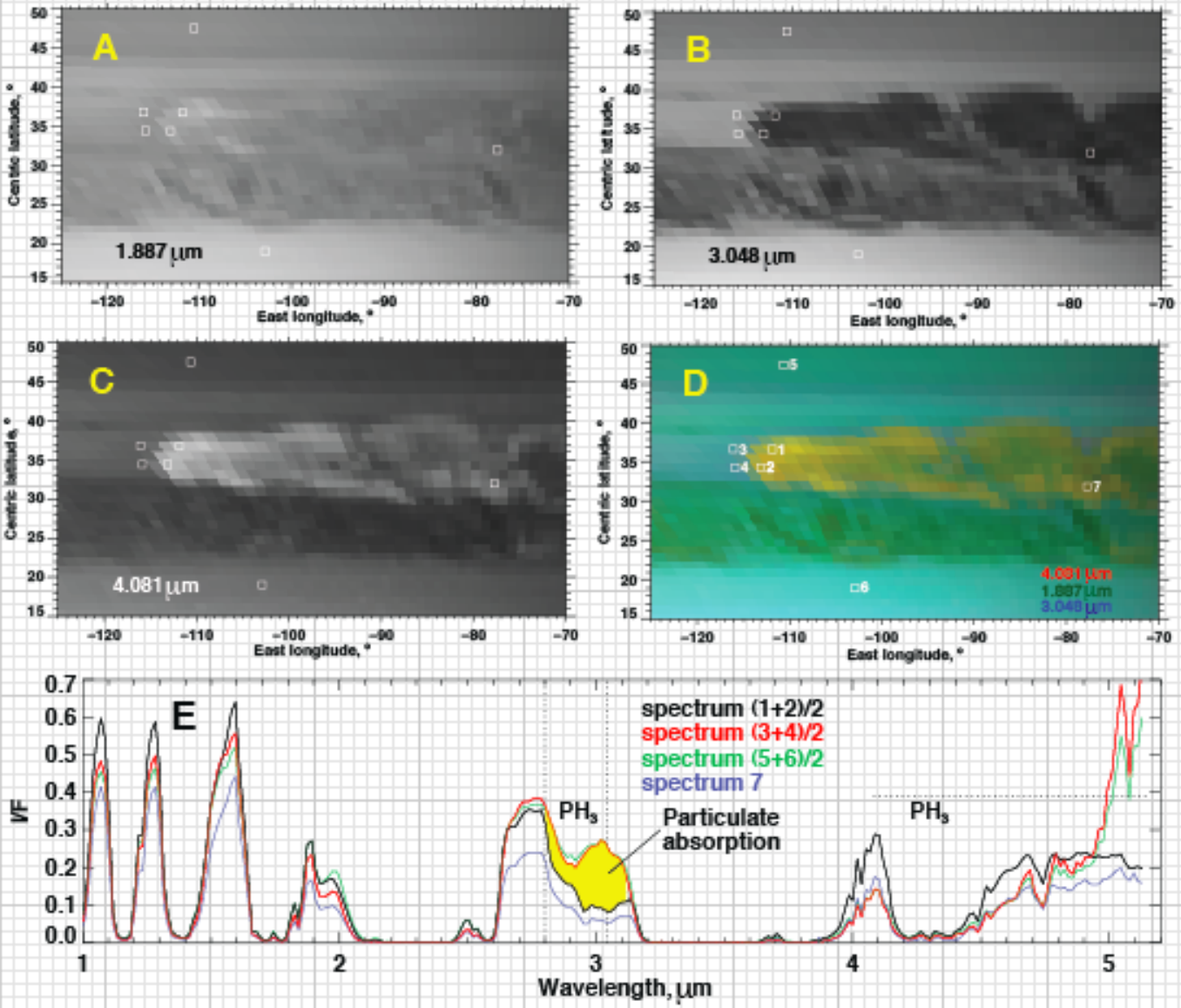
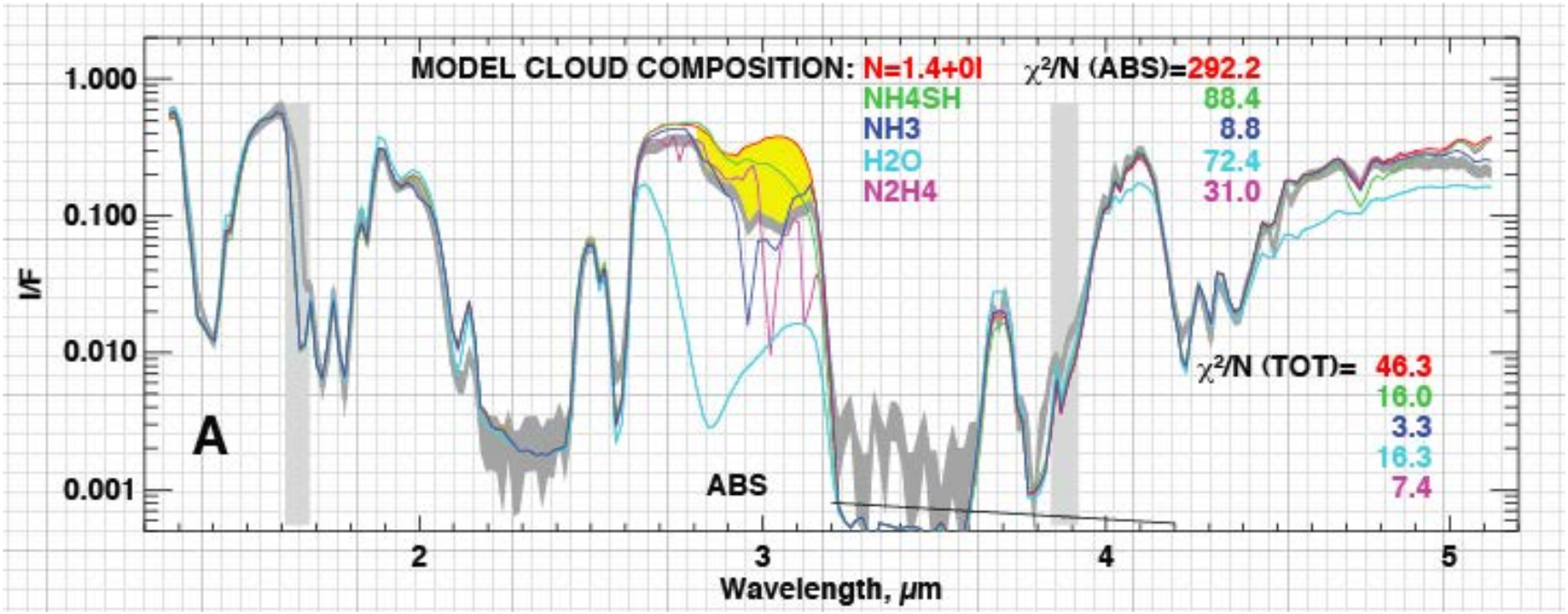


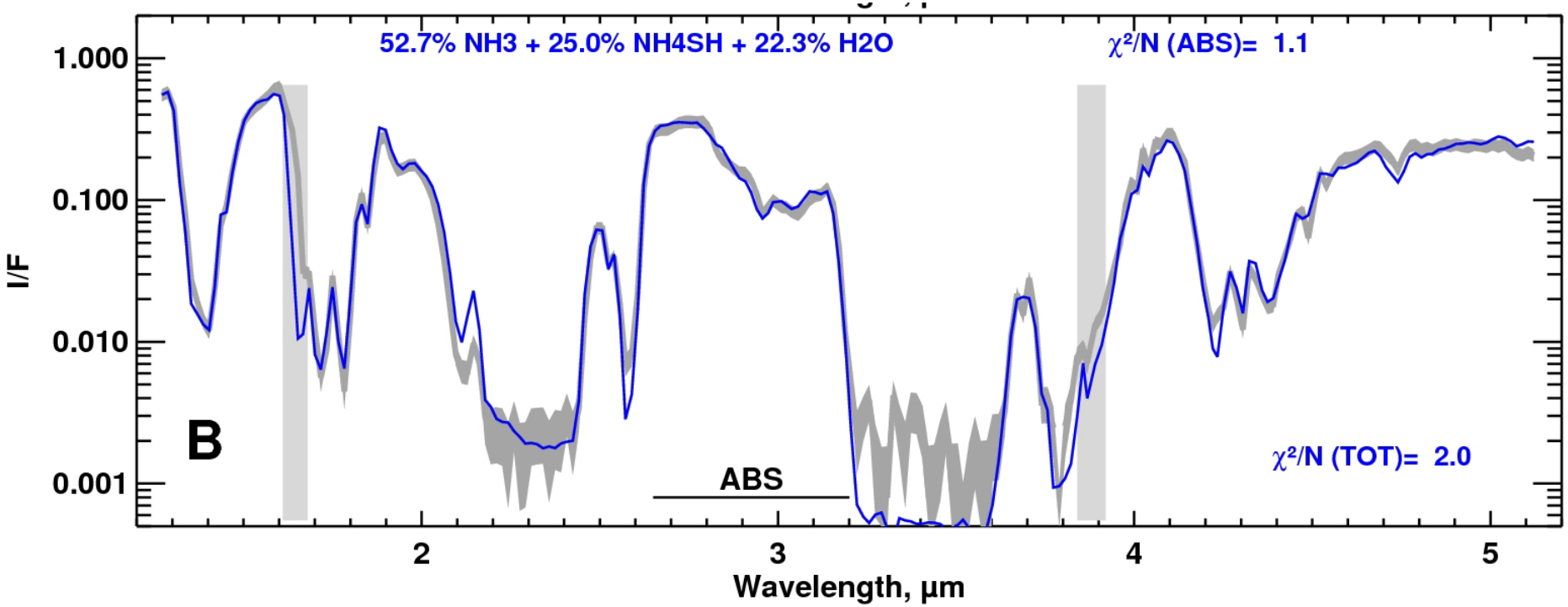
Figure 2: February 2010 Cassini VIMS images of Saturn's Great Storm at wavelengths of 1.887 (A), 3.048 (B), and 4.081 (C) microns, a color composite (D) and extracted spectra from several regions (E), showing evidence for particulate absorption near 3 μm . From Sromovsky et al. (2013).



RESULTS: NH3 is the best fit but no single absorber is a perfect fit.

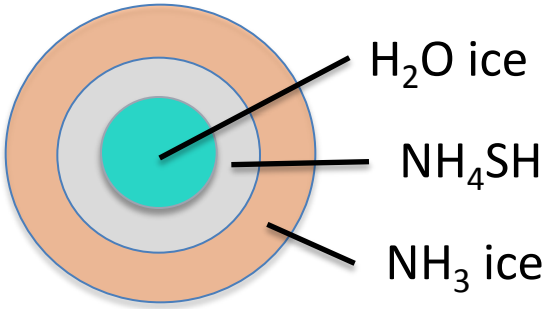
BUT…LINEAR COMBINATIONS OF PURE SPECTRA CAN FIT EXTREMELY WELL

(this is equivalent to a spatially heterogeneous model).



Cloud component fractions				Fit quality (Chisq/N)		
Non abs.	NH3	NH4SH	H2O	1.26-5.16 um	2.65-3.2 um	
	0.55	0.23	0.22	2.0	1.1	best fit
0.13	0.62		0.24	2.2	2.8	
0.0	0.83	0.17		3.7	5.2	poor fit w/o H_2O

More probable homogeneous model using coated particles.



It puts all components near the cloud top (needed for good spectral fits) using composite particles in which water ice provides the core and other materials coat that core as particles rise to higher and colder levels.

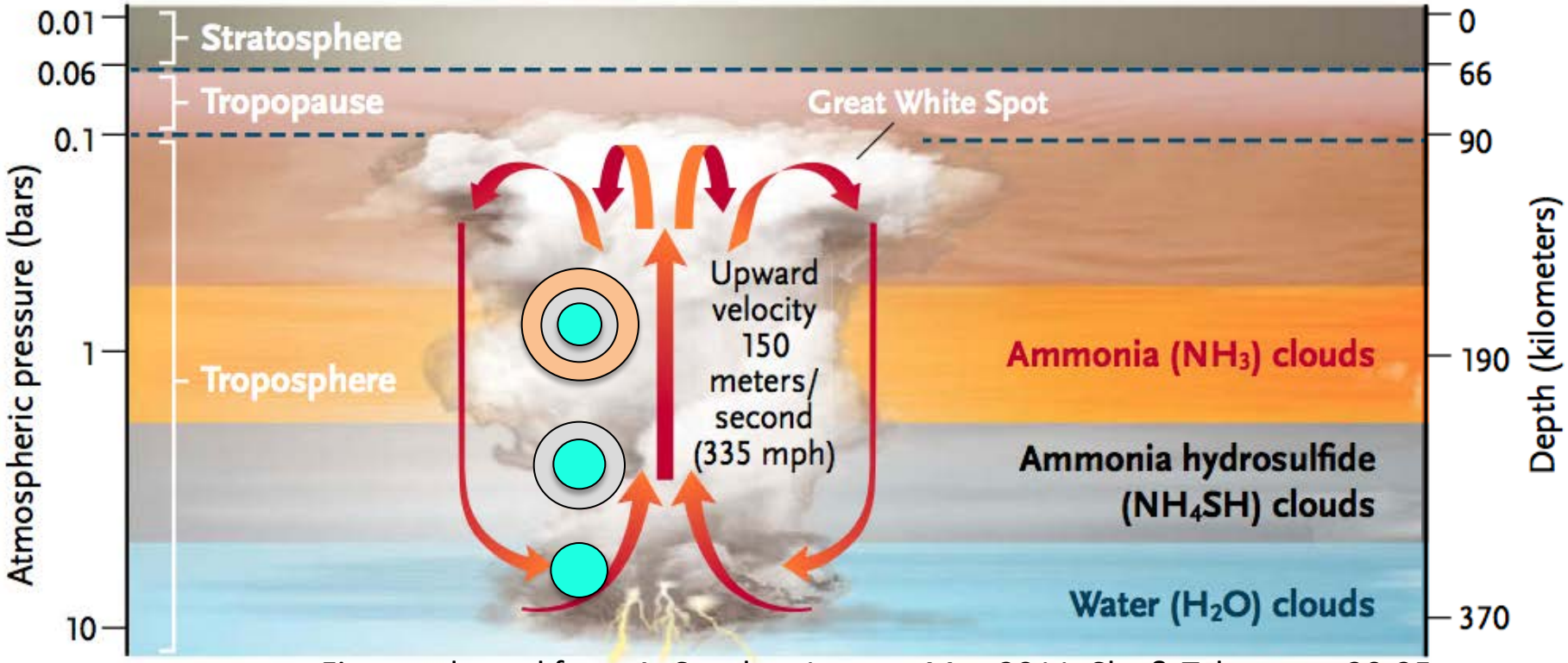
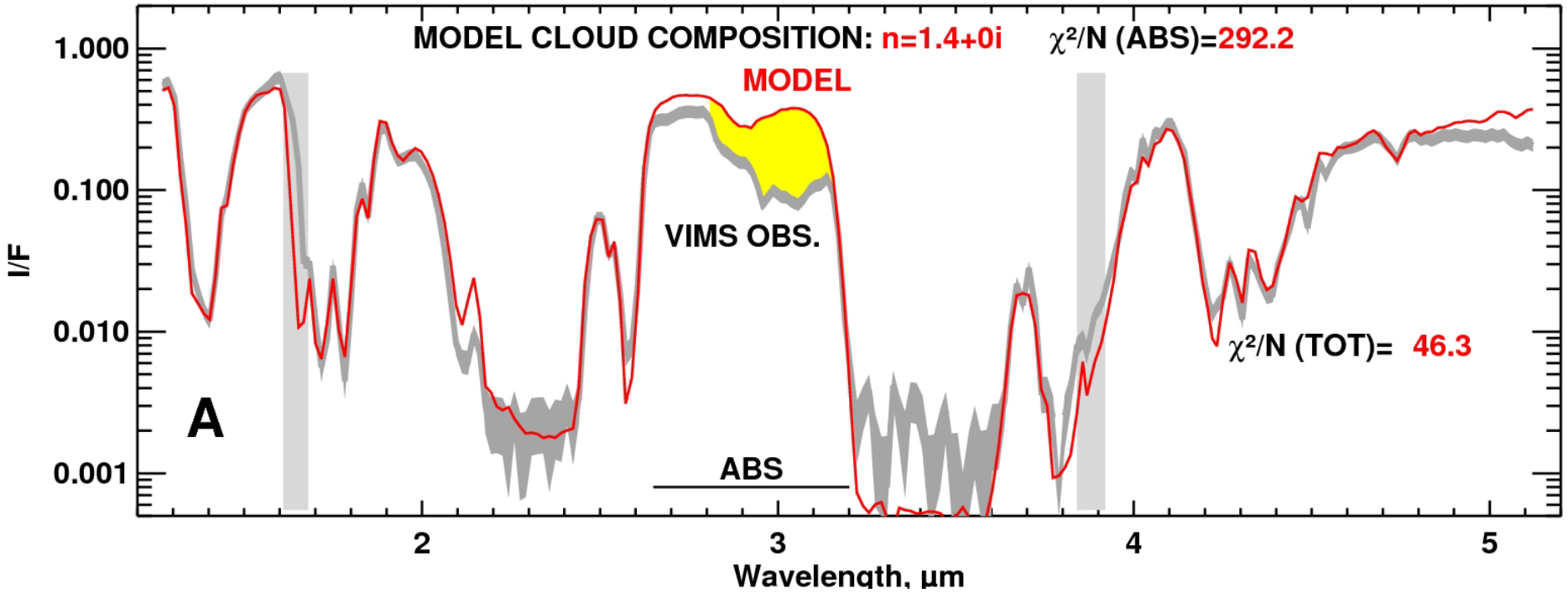


Figure adapted from A. Sanchez-Lavega, May 2011, Sky & Telescope, 20-25

Storm Head: First we try one absorber at a time in the main cloud layer

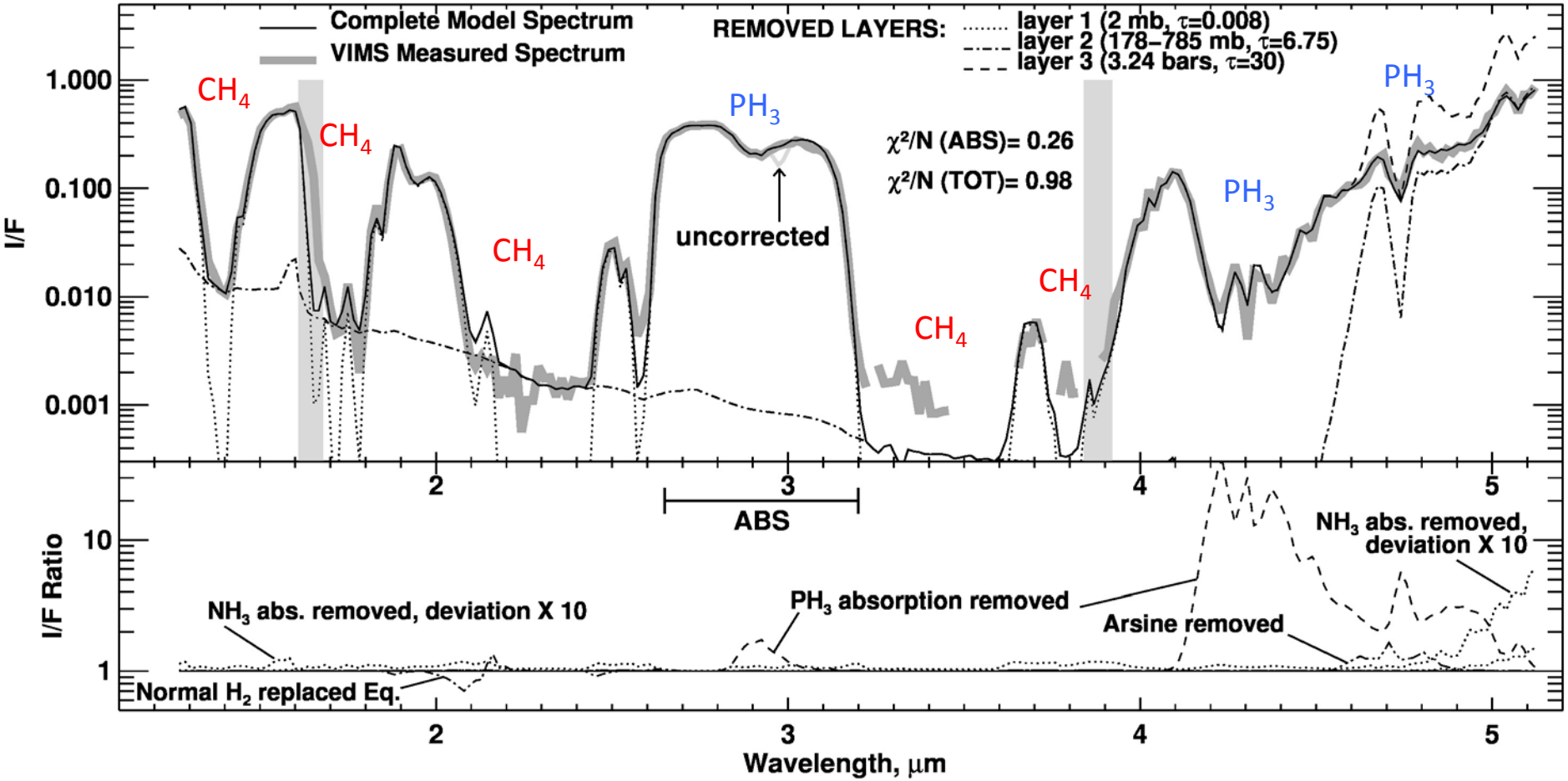
(1) Fit non-ABS region to get best vertical distribution (gas abs. constraints).

(2) Look in ABS region (2.7-3.65 um) to test the particle absorption fit.

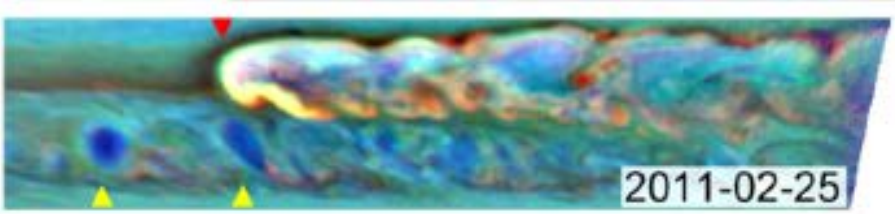


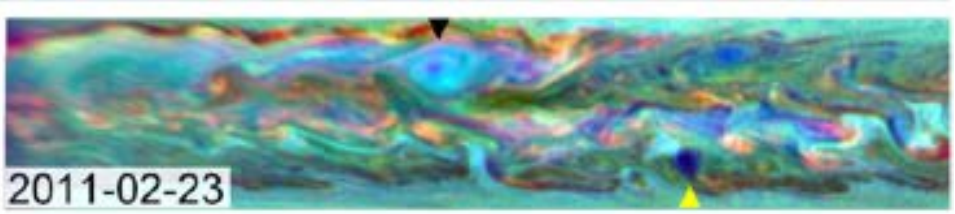
RESULTS: Non absorber is much too bright in ABS region.

Sanity check on modeling outside of storm region:
gas absorption features due to CH_4, PH_3, arsine, are well modelled,
three layer cloud model with non-absorbing particles fits very well,
correction/avoidance of spectrometer artifacts successful



Comparison of ISS and VIMS near-IR observations.





4.08 microns

Brighter than surroundings at 4.08 microns means larger particles.

3.05 microns

Dark at 3.05 microns means particles composed of C-H or N-H materials.

5.04 microns

Dark at 5.04 microns means optically thick (blocks thermal emission).

200°

Candidate 3-micron absorbers: (NH_3, NH_4SH, N_2H_4, H_2O, …)