

The background of the slide is a high-resolution aerial photograph of Earth from space, showing a vast expanse of blue oceans and white, fluffy clouds scattered across the horizon.

Molecular Detectability in Exoplanetary Emission Spectra

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Giovanna Tinetti, Giorgio Savini and Enzo Pascale

Warm Neptune

Minimum detectable abundances

	CH_4		CO		CO_2		
SNR	$3.3 \mu m$	$8 \mu m$	$2.3 \mu m$	$4.6 \mu m$	$2.8 \mu m$	$4.3 \mu m$	$15 \mu m$
10 / R=100	10^{-7}	10^{-6}	10^{-3}	10^{-5}	10^{-6}	10^{-7}	10^{-6}
5 / R=50	10^{-6}	10^{-5}	10^{-3}	10^{-4}	10^{-6}	10^{-7}	10^{-5}

	NH_3				HCN		
SNR	$2.2 \mu m$	$3 \mu m$	$6.1 \mu m$	$10.5 \mu m$	$3 \mu m$	$7 \mu m$	$14 \mu m$
10 / R=100	10^{-5}	10^{-6}	10^{-6}	10^{-6}	10^{-6}	10^{-5}	10^{-6}
5 / R=50	10^{-4}	10^{-5}	10^{-5}	10^{-5}	10^{-6}	10^{-4}	10^{-5}

	C_2H_6		H_2S			C_2H_2		
SNR	$3.3 \mu m$	$12.2 \mu m$	$2.6 \mu m$	$4.25 \mu m$	$8 \mu m$	$3 \mu m$	$7.5 \mu m$	$13.7 \mu m$
10 / R=100	10^{-5}	10^{-5}	10^{-5}	10^{-4}	10^{-3}	10^{-7}	10^{-4}	10^{-6}
5 / R=50	10^{-4}	10^{-5}	10^{-4}	10^{-3}	-	10^{-6}	10^{-3}	10^{-5}

	PH_3		H_2O		
SNR	$4.3 \mu m$	$10 \mu m$	$2.8 \mu m$	$5 - 8 \mu m$	$11 - 16 \mu m$
10 / R=100	10^{-7}	10^{-6}	10^{-6}	10^{-5}	10^{-4}
5 / R=50	10^{-6}	10^{-5}	10^{-5}	10^{-5}	10^{-4}

Warm Neptune

Minimum detectable abundances

SNR	CH_4		CO		CO_2		
	$3.3 \mu m$	$8 \mu m$	$2.3 \mu m$	$4.6 \mu m$	$2.8 \mu m$	$4.3 \mu m$	$15 \mu m$
10 / R=100	10^{-7}	10^{-6}	10^{-3}	10^{-5}	10^{-6}	10^{-7}	10^{-6}
5 / R=50	10^{-6}	10^{-5}	10^{-3}	10^{-4}	10^{-6}	10^{-7}	10^{-5}

SNR	NH_3				HCN		
	$2.2 \mu m$	$3 \mu m$	$6.1 \mu m$	$10.5 \mu m$	$3 \mu m$	$7 \mu m$	$14 \mu m$
10 / R=100	10^{-5}	10^{-6}	10^{-6}	10^{-6}	10^{-6}	10^{-5}	10^{-6}
5 / R=50	10^{-4}	10^{-5}	10^{-5}	10^{-5}	10^{-6}	10^{-4}	10^{-5}

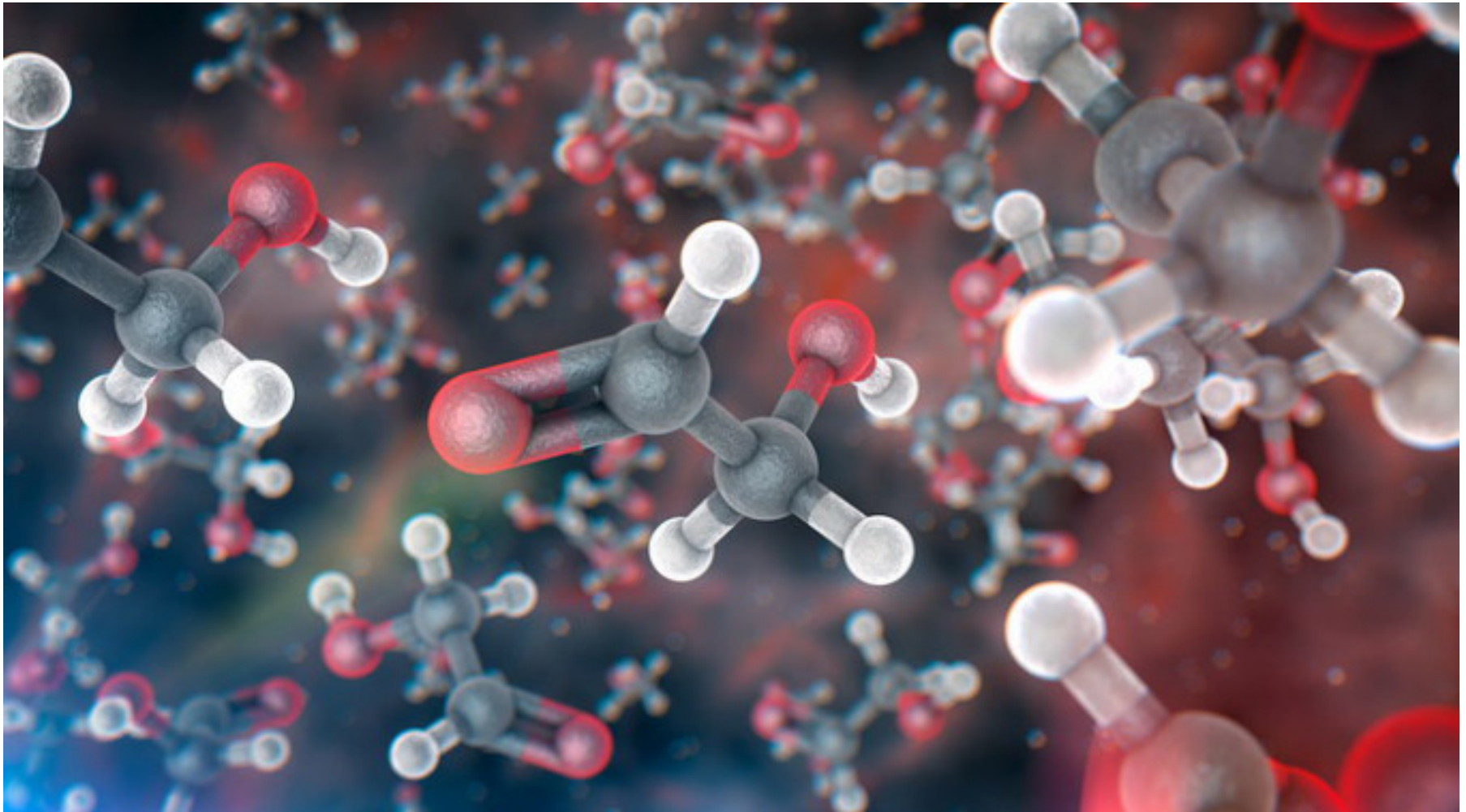
CHEMICAL CENSUS & ORIGIN

SNR	C_2H_6		H_2S			C_2H_2		
	$3.3 \mu m$	$12.2 \mu m$	$2.6 \mu m$	$4.25 \mu m$	$8 \mu m$	$3 \mu m$	$7.5 \mu m$	$13.7 \mu m$
10 / R=100	10^{-5}	10^{-5}	10^{-5}	10^{-4}	10^{-3}	10^{-7}	10^{-4}	10^{-6}
5 / R=50	10^{-4}	10^{-5}	10^{-4}	10^{-3}	-	10^{-6}	10^{-3}	10^{-5}

SNR	PH_3		H_2O		
	$4.3 \mu m$	$10 \mu m$	$2.8 \mu m$	$5 - 8 \mu m$	$11 - 16 \mu m$
10 / R=100	10^{-7}	10^{-6}	10^{-6}	10^{-5}	10^{-4}
5 / R=50	10^{-6}	10^{-5}	10^{-5}	10^{-5}	10^{-4}

Chemical Census

Exploring the exoplanetary chemical diversity



Chemical Census

Exploring the exoplanetary chemical diversity

- ~130 targets
- Observed “quickly” to get ~SNR 5
- Low resolutions:
 - R=50 1-5 μ m
 - R=30 5-16 μ m

Origin

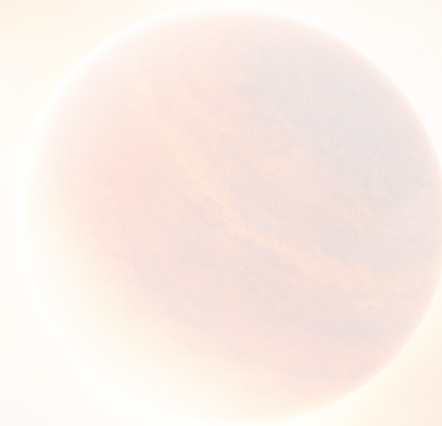
Understanding the origin of exoplanetary diversity



Origin

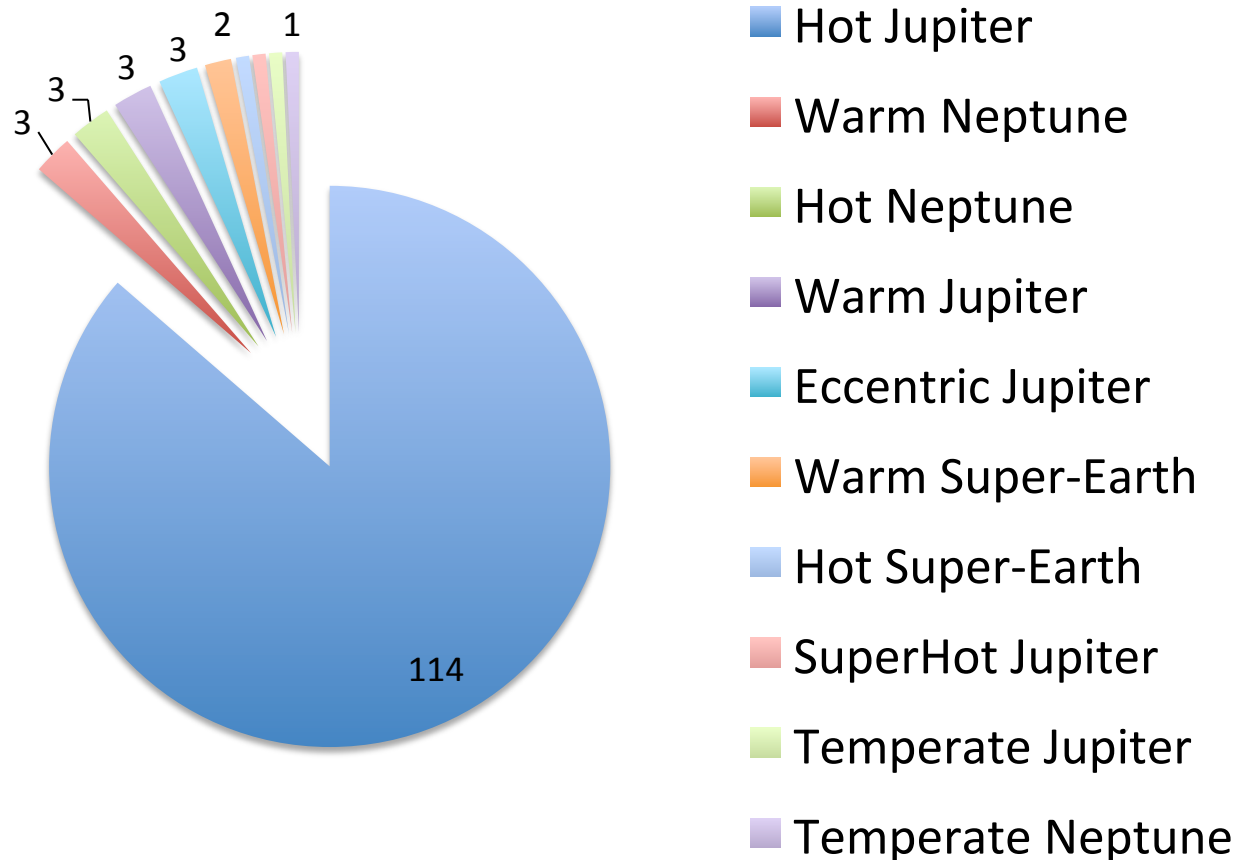
Understanding the origin of exoplanetary diversity

- ~50/60 targets
- SNR~10
- Better resolution
 - R=100 1-5 μ m
 - R=30 5-16 μ m



Currently available Planets - CC

Number of planets per type



Planets

Jupiter-type

Neptune-type

Super Earth

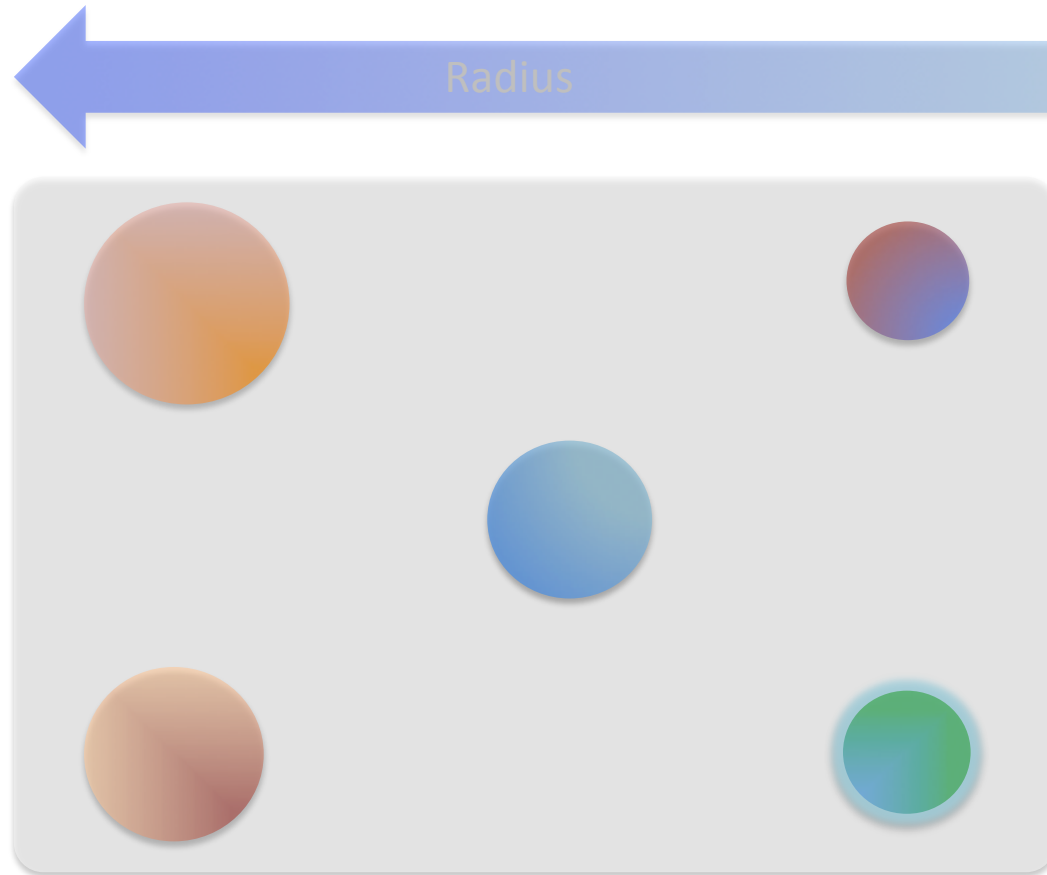
Radius

'Hot'
(850-1500K)

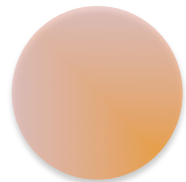
'Warm'
(500-800K)

'Habitable Zone'
(250-350K)

Temperature



Molecules tested

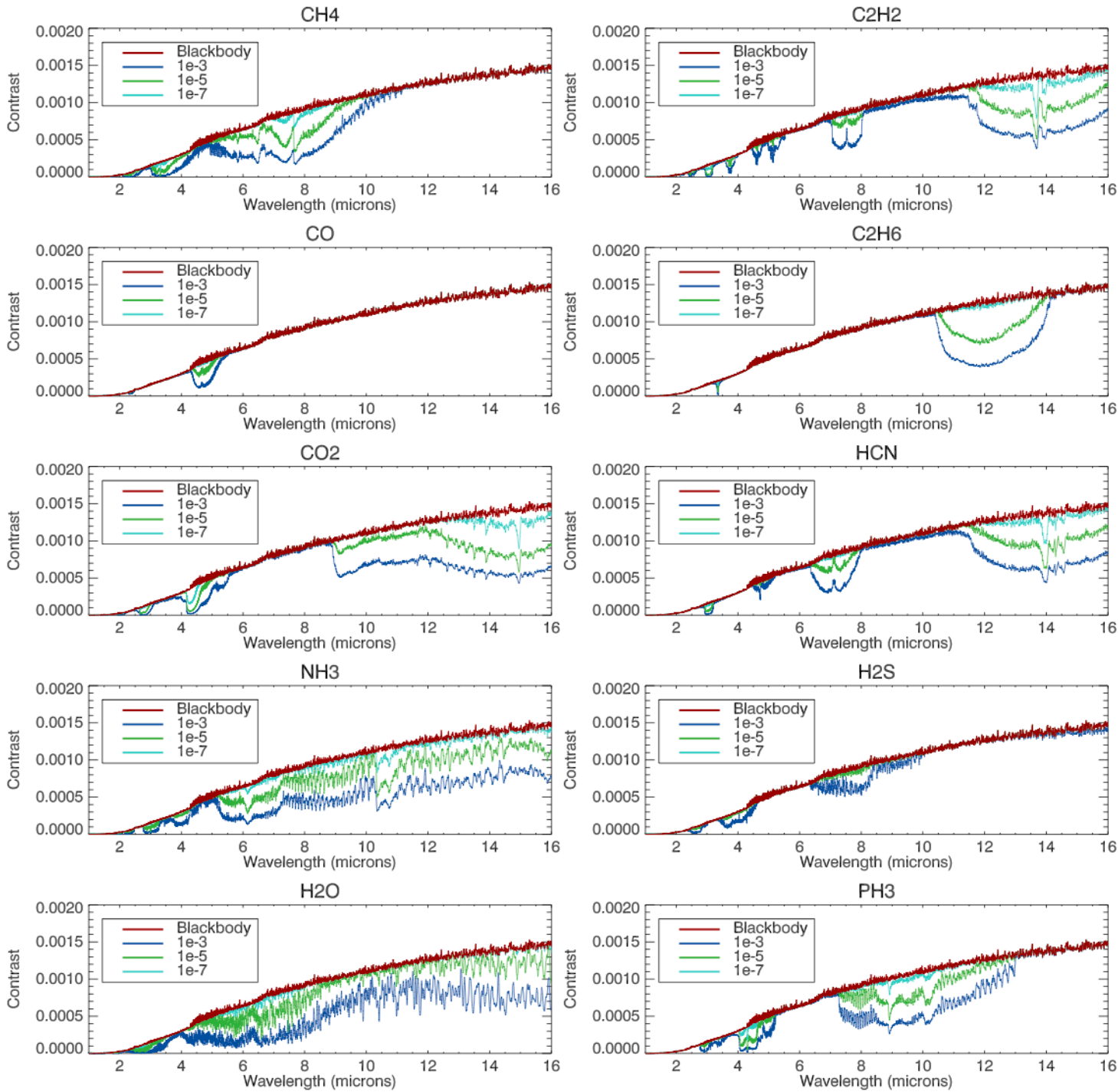


Planet	Molecules considered
Hot Jupiter	CH ₄ , CO, CO ₂ , NH ₃ , H ₂ O, C ₂ H ₂ , C ₂ H ₆ , HCN, H ₂ S, PH ₃
Hot super-Earth	H ₂ O, CO and CO ₂
Warm Neptune	CH ₄ , CO, CO ₂ , NH ₃ , H ₂ O, C ₂ H ₂ , C ₂ H ₆ , HCN, H ₂ S, PH ₃
Temperate Jupiter	H ₂ O, CH ₄ , CO ₂ , C ₂ H ₂ and C ₂ H ₆
Temperate super-Earth	H ₂ O, CO ₂ , NH ₃ and O ₃





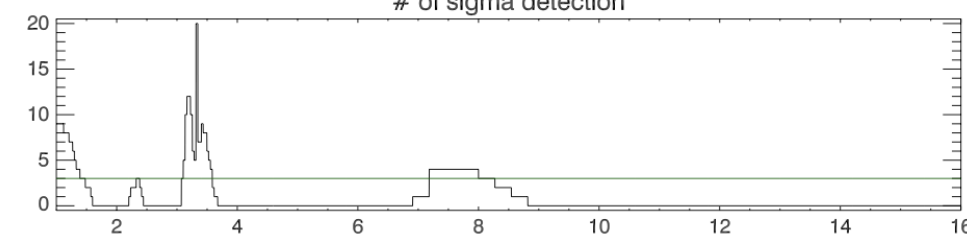
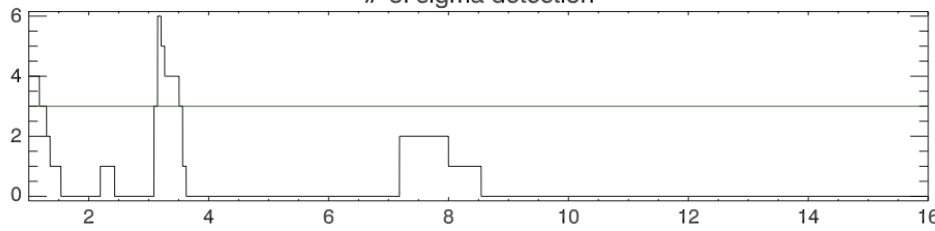
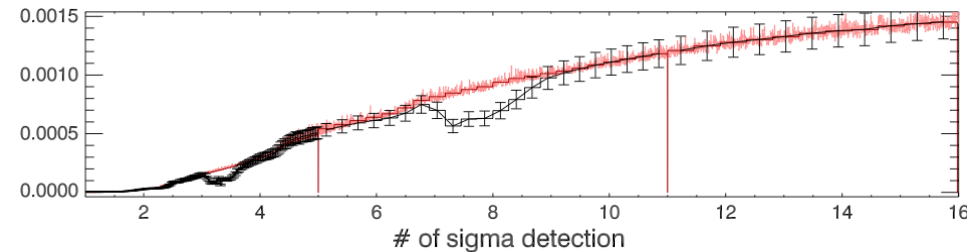
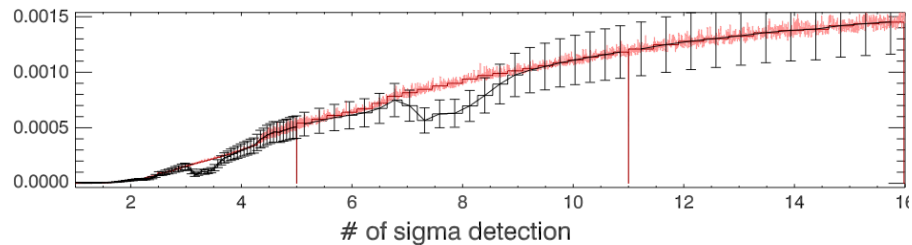
Warm Neptune



Fixed SNR tests

- Instrument independent
- Check for deviation from continuum in every WL bin
- Fix SNR = 5, 10 (and 20)
- Detection if deviation ≥ 3 sigma
- Mixing ratios: $1e-3$ to $1e-7$

e.g.: Warm Neptune, CH_4 @ $1e-6$



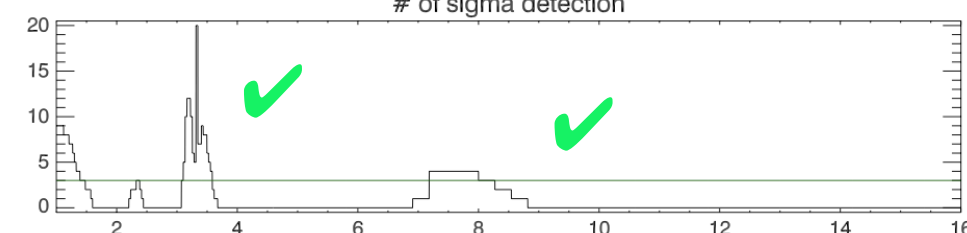
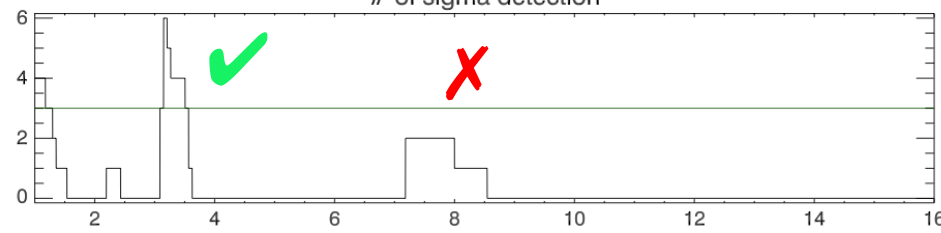
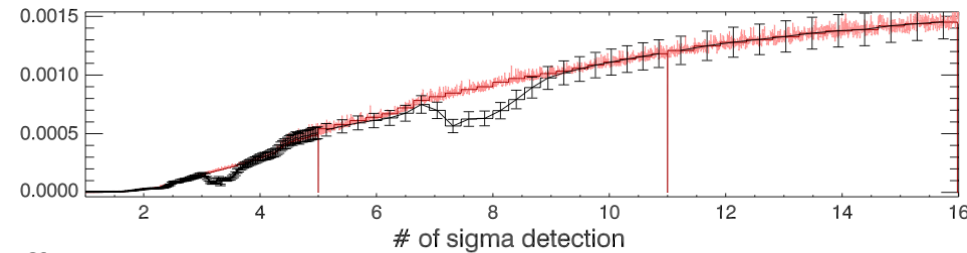
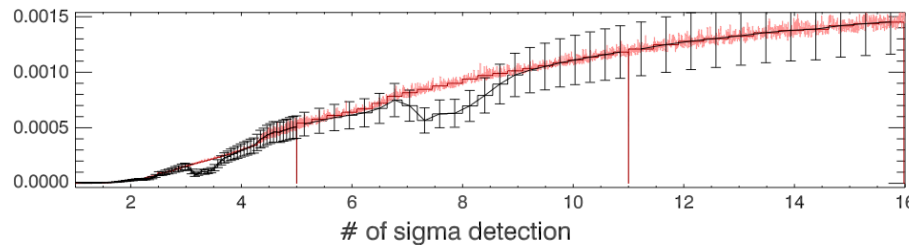
Chemical Census: SNR 5, $R=50$ ($1-5\mu\text{m}$)

Deep Survey: SNR 10, $R=100$ ($1-5\mu\text{m}$)

Fixed SNR tests

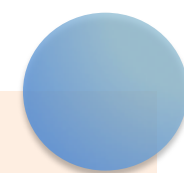
- Instrument independent
- Fix SNR = 5, 10 (and 20)
- Mixing ratios: 1e-3 to 1e-7
- Check for deviation from continuum in every WL bin
- Detection if deviation ≥ 3 sigma

e.g.: Warm Neptune, CH₄ @ 1e-6



Chemical Census: SNR 5, R=50 (1-5 μ m)

Deep Survey: SNR 10, R=100 (1-5 μ m)



Warm Neptune

Minimum detectable abundances

R=50/100 @ λ 1-5 μ m

R=30 @ λ >5 μ m

SNR	CH_4		CO		CO_2		
	3.3 μ m	8 μ m	2.3 μ m	4.6 μ m	2.8 μ m	4.3 μ m	15 μ m
10 / R=100	10^{-7}	10^{-6}	10^{-3}	10^{-5}	10^{-6}	10^{-7}	10^{-6}
5 / R=50	10^{-6}	10^{-5}	10^{-3}	10^{-4}	10^{-6}	10^{-7}	10^{-5}

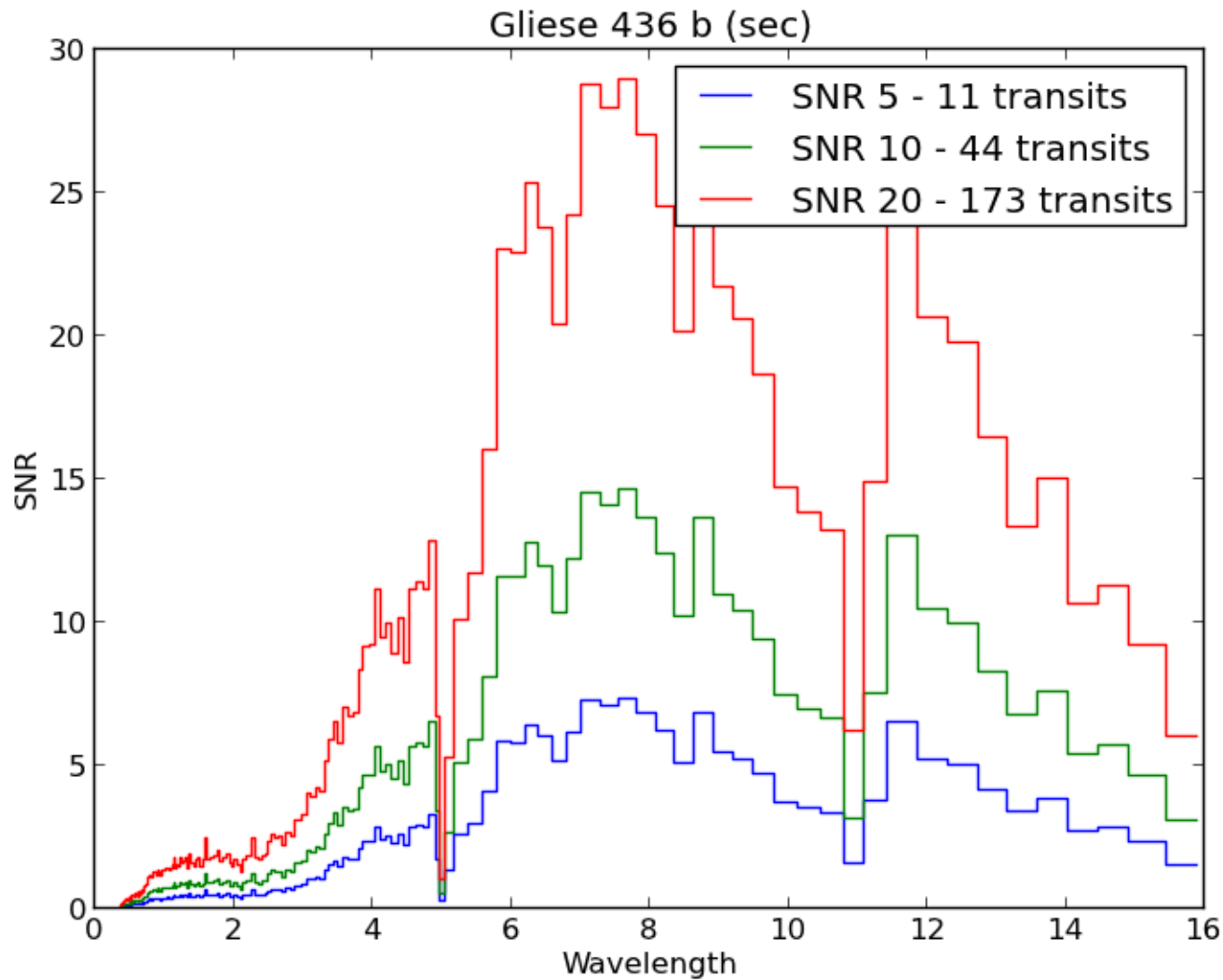
SNR	NH_3				HCN		
	2.2 μ m	3 μ m	6.1 μ m	10.5 μ m	3 μ m	7 μ m	14 μ m
10 / R=100	10^{-5}	10^{-6}	10^{-6}	10^{-6}	10^{-6}	10^{-5}	10^{-6}
5 / R=50	10^{-4}	10^{-5}	10^{-5}	10^{-5}	10^{-6}	10^{-4}	10^{-5}

SNR	C_2H_6		H_2S			C_2H_2		
	3.3 μ m	12.2 μ m	2.6 μ m	4.25 μ m	8 μ m	3 μ m	7.5 μ m	13.7 μ m
10 / R=100	10^{-5}	10^{-5}	10^{-5}	10^{-4}	10^{-3}	10^{-7}	10^{-4}	10^{-6}
5 / R=50	10^{-4}	10^{-5}	10^{-4}	10^{-3}	-	10^{-6}	10^{-3}	10^{-5}

SNR	PH_3		H_2O		
	4.3 μ m	10 μ m	2.8 μ m	5 - 8 μ m	11 - 16 μ m
10 / R=100	10^{-7}	10^{-6}	10^{-6}	10^{-5}	10^{-4}
5 / R=50	10^{-6}	10^{-5}	10^{-5}	10^{-5}	10^{-4}

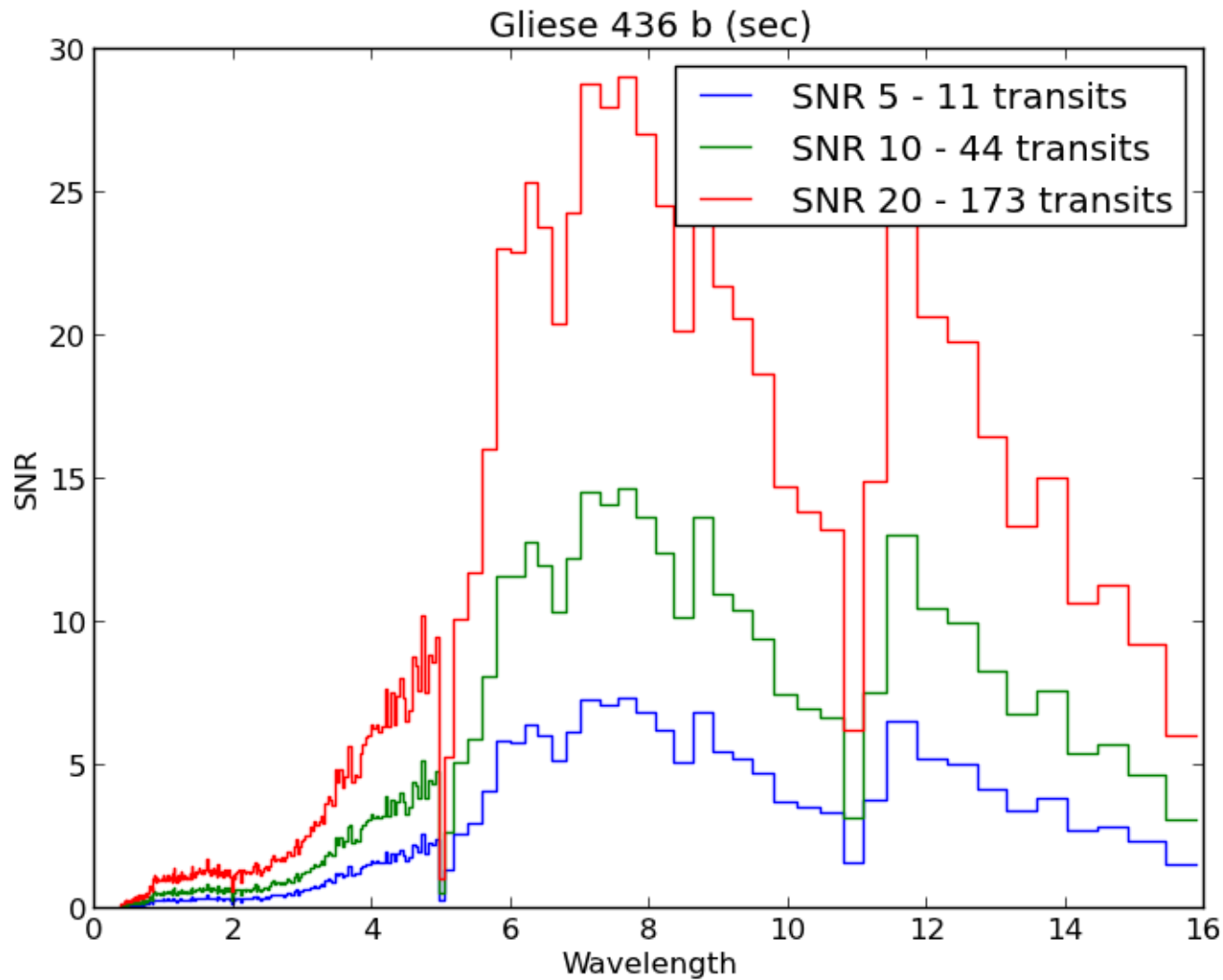


Warm Neptune, $R=50$ @ $\lambda 1-5 \mu\text{m}$, $R30$ @ $\lambda 5-16 \mu\text{m}$



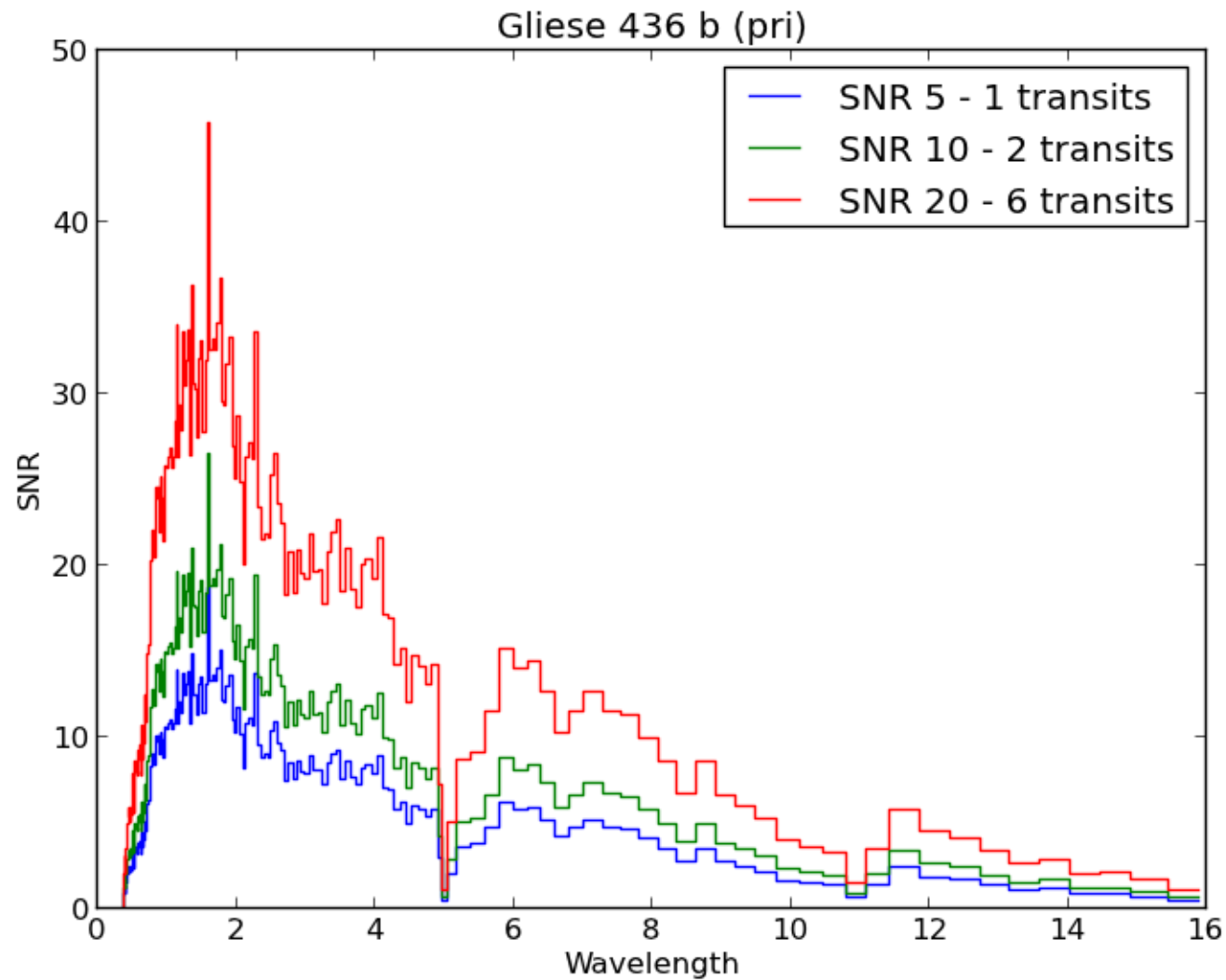


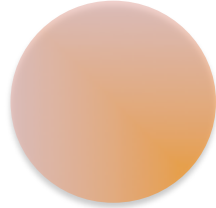
Warm Neptune, $R=100$ @ $\lambda 1-5 \mu\text{m}$, $R30$ @ $\lambda 5-16 \mu\text{m}$



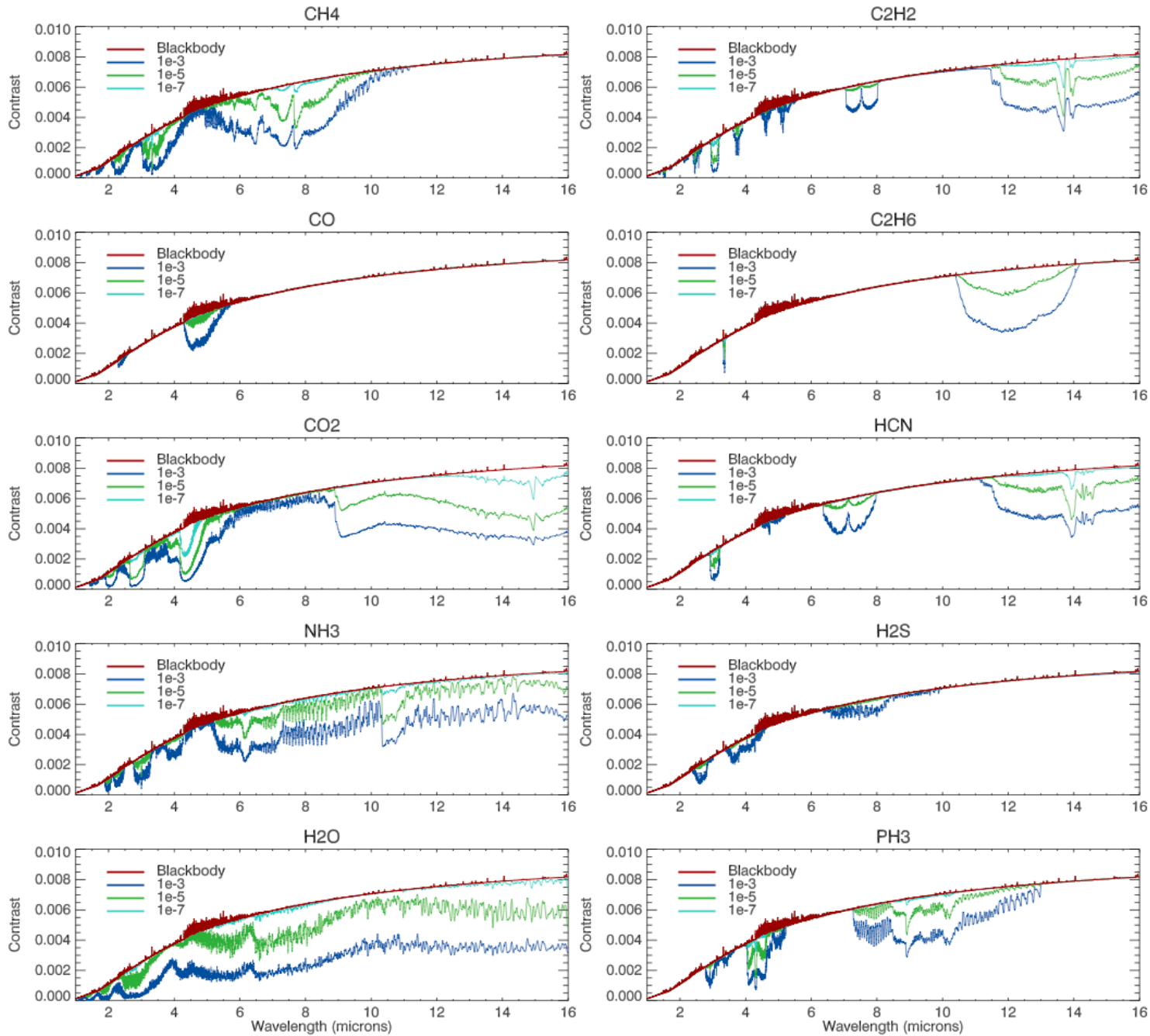


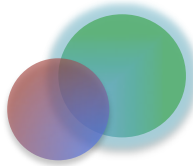
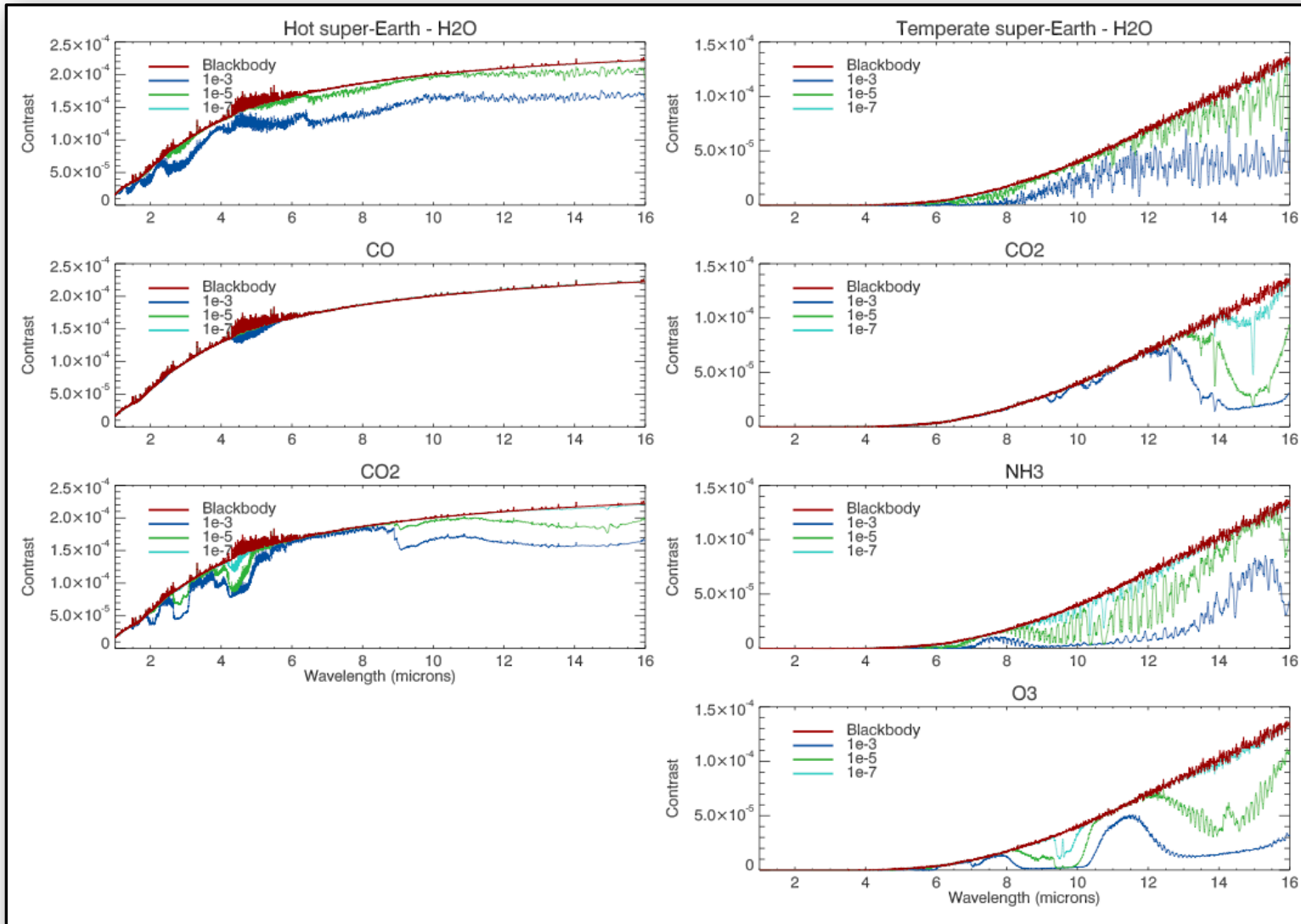
PRIMARY - Warm Neptune, $R=50$ @ $\lambda 1-5 \mu\text{m}$, $R30$ @ $\lambda 5-16 \mu\text{m}$



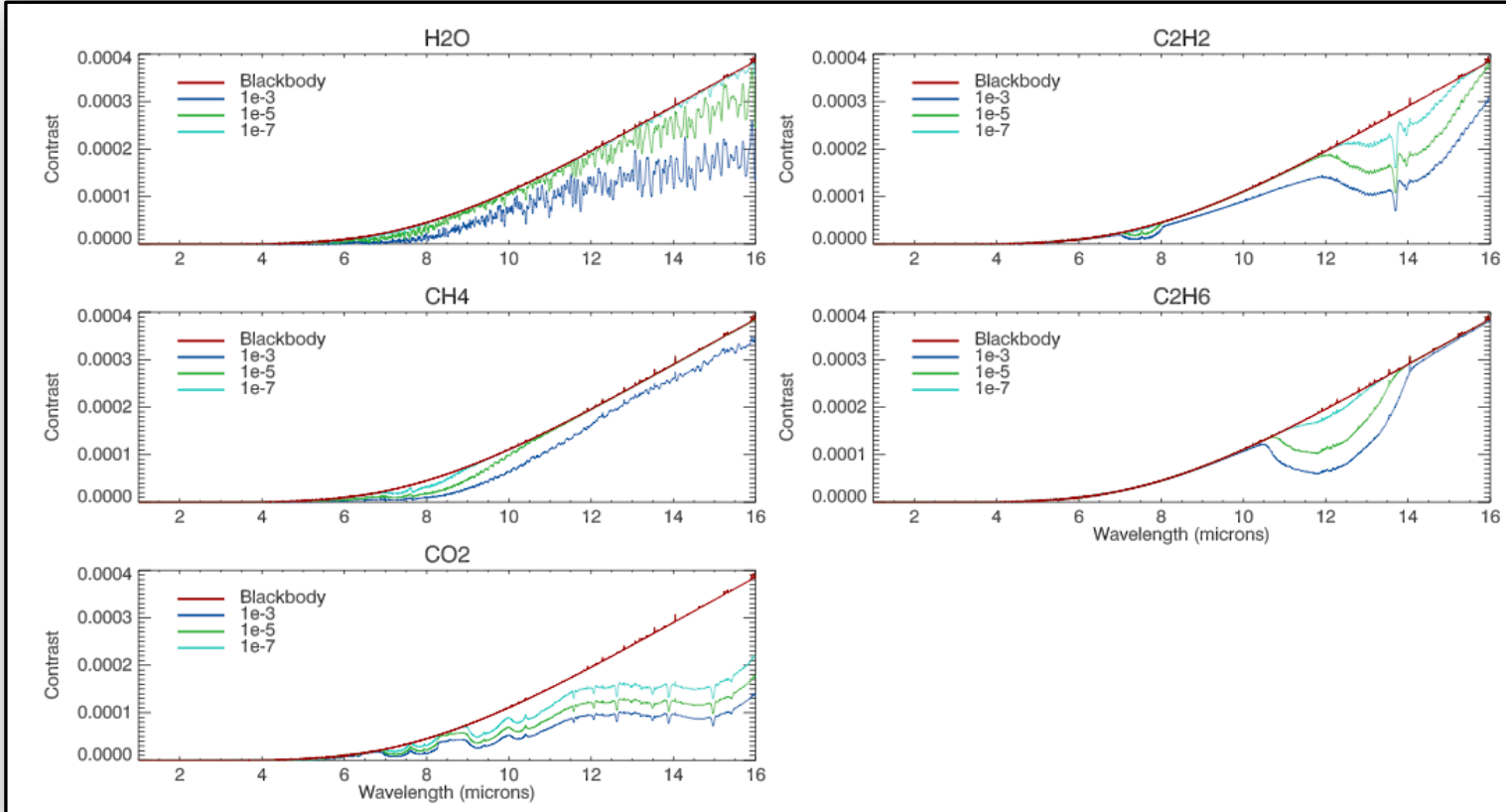


Hot Jupiter

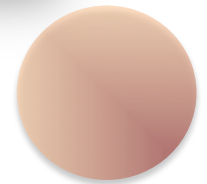




Hot &
temperate
super-Earth



temperate Jupiter



SNR	CH_4		CO		CO_2		
	$3.3 \mu m$	$8 \mu m$	$2.3 \mu m$	$4.6 \mu m$	$2.8 \mu m$	$4.3 \mu m$	$15 \mu m$
20 / R=300	10^{-6}	10^{-5}	10^{-3}	10^{-5}	10^{-6}	10^{-7}	10^{-6}
10 / R=100	10^{-6}	10^{-5}	-	10^{-4}	10^{-6}	10^{-7}	10^{-6}
5 / R=50	10^{-5}	10^{-4}	-	10^{-3}	10^{-6}	10^{-7}	10^{-5}

SNR	NH_3			HCN		
	$3 \mu m$	$6.1 \mu m$	$10.5 \mu m$	$3 \mu m$	$7 \mu m$	$14 \mu m$
20 / R=300	10^{-5}	10^{-5}	10^{-6}	10^{-6}	10^{-4}	10^{-5}
10 / R=100	10^{-4}	10^{-5}	10^{-5}	10^{-5}	10^{-3}	10^{-4}
5 / R=50	10^{-4}	10^{-4}	10^{-4}	10^{-4}	-	10^{-3}

SNR	C_2H_6		H_2S			C_2H_2		
	$3.3 \mu m$	$12.2 \mu m$	$2.6 \mu m$	$4.25 \mu m$	$8 \mu m$	$3 \mu m$	$7.5 \mu m$	$13.7 \mu m$
20 / R=300	10^{-4}	10^{-5}	10^{-4}	10^{-3}	-	10^{-7}	10^{-3}	10^{-4}
10 / R=100	10^{-4}	10^{-4}	10^{-4}	10^{-3}	-	10^{-6}	10^{-3}	10^{-4}
5 / R=50	-	10^{-3}	10^{-3}	-	-	10^{-5}	-	10^{-4}

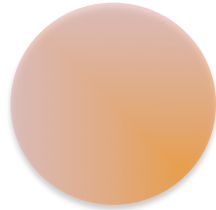
SNR	PH_3		H_2O		
	$4.3 \mu m$	$10 \mu m$	$2.8 \mu m$	$5 - 8 \mu m$	$11 - 16 \mu m$
20 / R=300	10^{-7}	10^{-5}	10^{-6}	10^{-6}	10^{-5}
10 / R=100	10^{-6}	10^{-4}	10^{-5}	10^{-5}	10^{-5}
5 / R=50	10^{-5}	10^{-3}	10^{-5}	10^{-4}	10^{-4}

Hot Jupiter

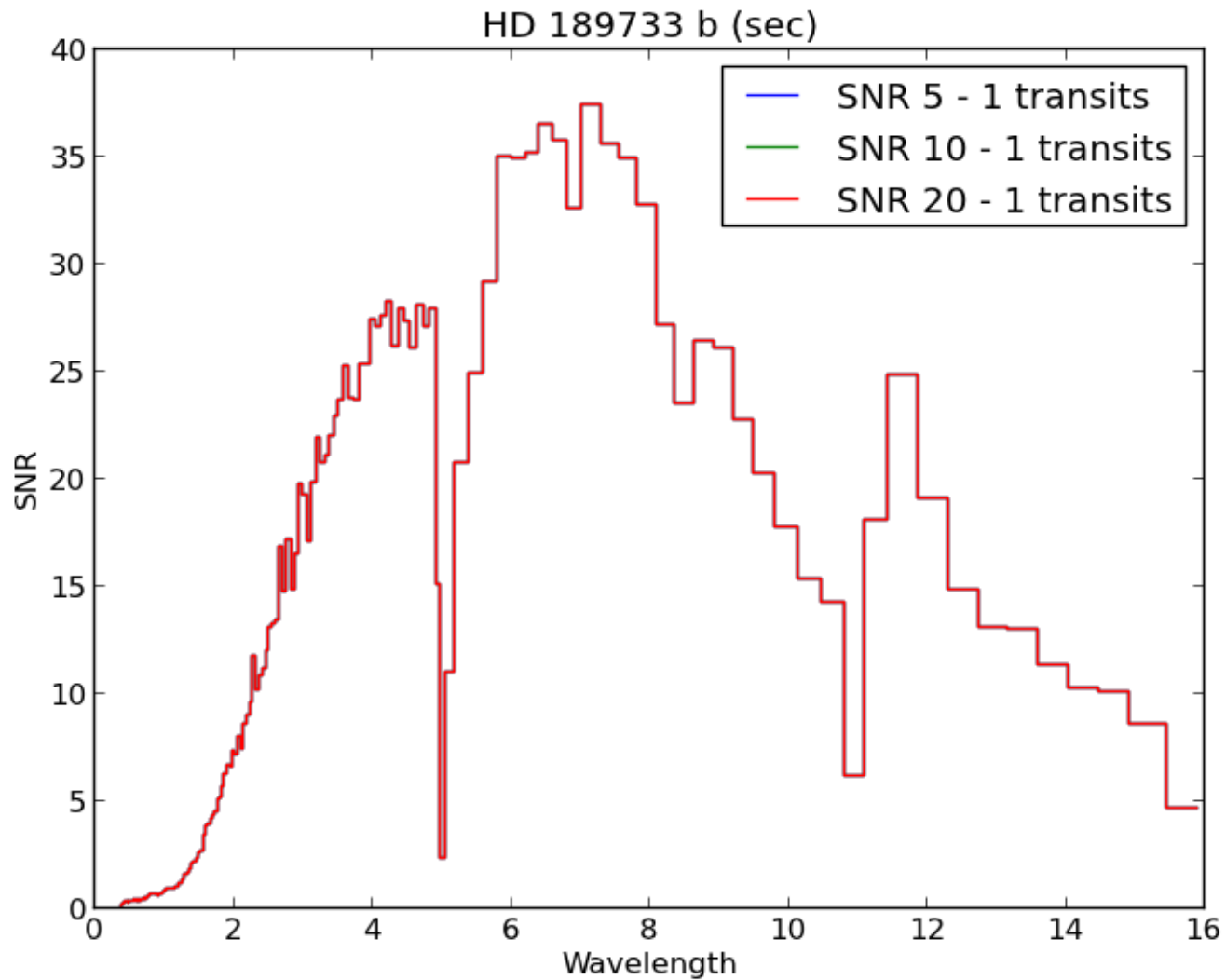
Minimum detectable abundances

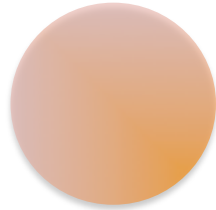
R=50/100/300 @ λ 1-5 μm

R=30 @ $\lambda > 5 \mu m$

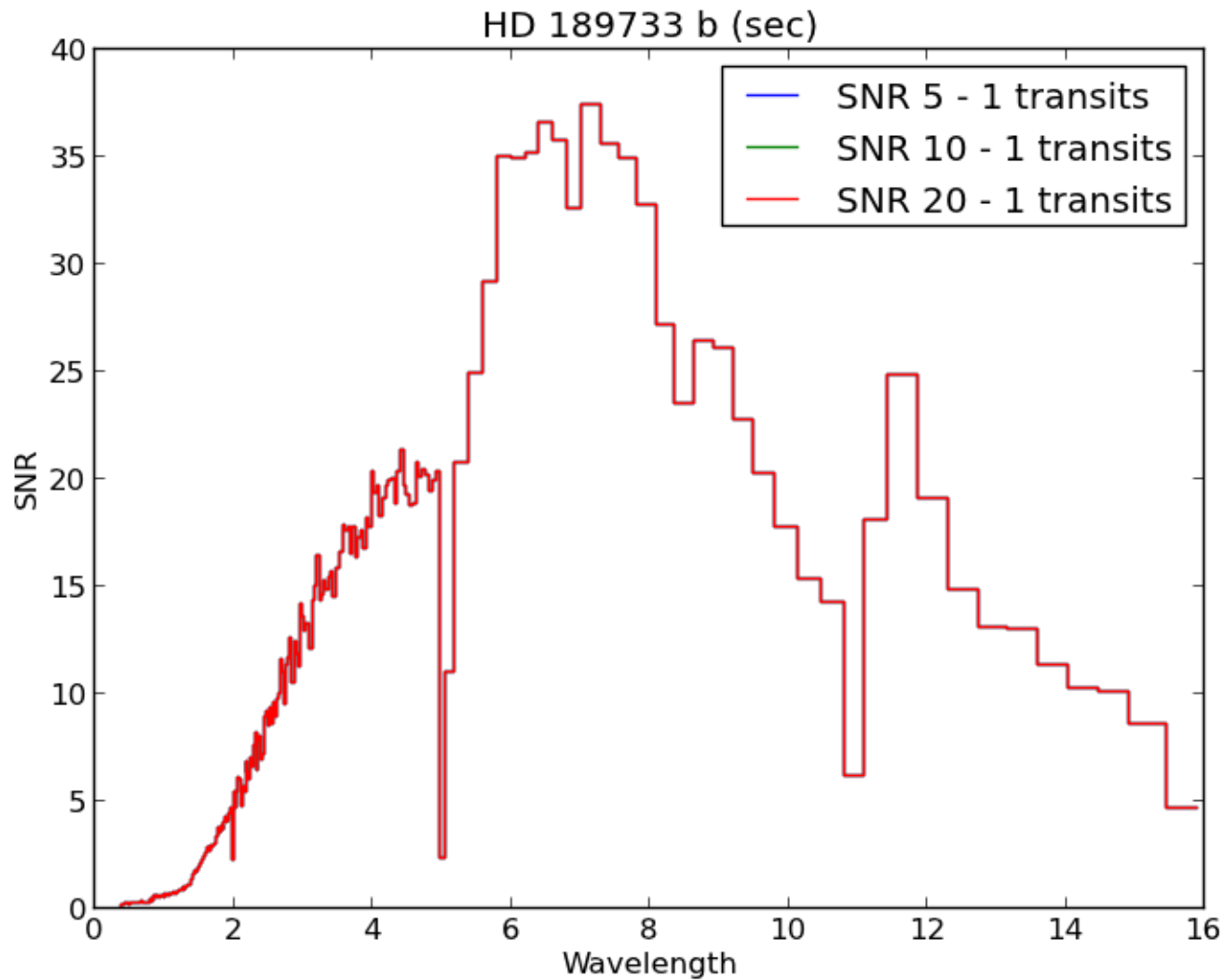


Hot Jupiter, $R=50$ @ $\lambda 1-5 \mu\text{m}$, $R30$ @ $\lambda 5-16 \mu\text{m}$

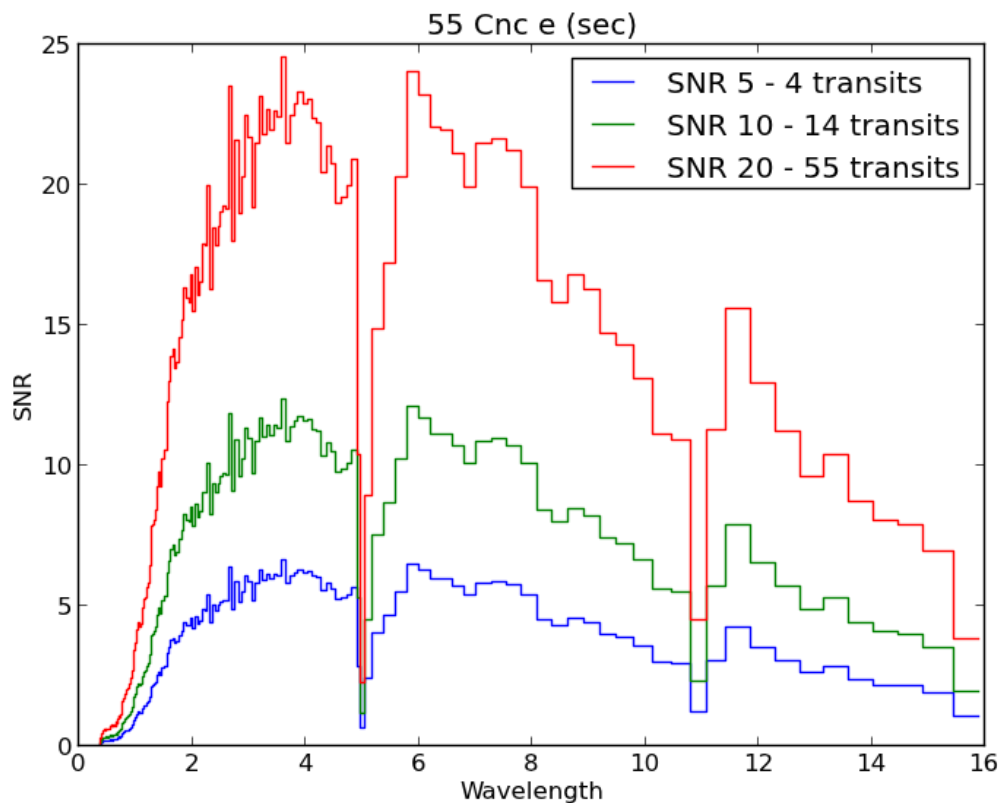




Hot Jupiter, $R=100$ @ $\lambda 1-5 \mu\text{m}$, $R30$ @ $\lambda 5-16 \mu\text{m}$



SNR	H_2O			CO_2			CO	
	$2.8 \mu m$	$5 - 8 \mu m$	$11 - 16 \mu m$	$2.8 \mu m$	$4.3 \mu m$	$15 \mu m$	$2.3 \mu m$	$4.6 \mu m$
10 / R=100	10^{-3}	10^{-3}	10^{-3}	10^{-5}	10^{-6}	10^{-4}	-	-
5 / R=50	10^{-3}	-	-	10^{-4}	10^{-5}	-	-	-



Hot super-Earth

Minimum detectable abundances

R=50/100 @ λ 1-5 μm

R=30 @ λ >5 μm

SNR	H_2O		CO_2	CH_4	C_2H_2		C_2H_6
	5 - 8 μm	11 - 16 μm	15 μm	8 μm	7.5 μm	13.7 μm	12.2 μm
20	10^{-6}	10^{-5}	10^{-7}	10^{-7}	10^{-6}	10^{-7}	10^{-6}
10	10^{-6}	10^{-4}	10^{-7}	10^{-7}	10^{-5}	10^{-6}	10^{-6}
5	10^{-5}	10^{-3}	10^{-7}	10^{-6}	10^{-4}	10^{-5}	10^{-5}

Temperate Jupiter

Minimum detectable abundances

R=30 @ $\lambda > 5 \mu m$

Temperate super-Earth

Minimum detectable abundances

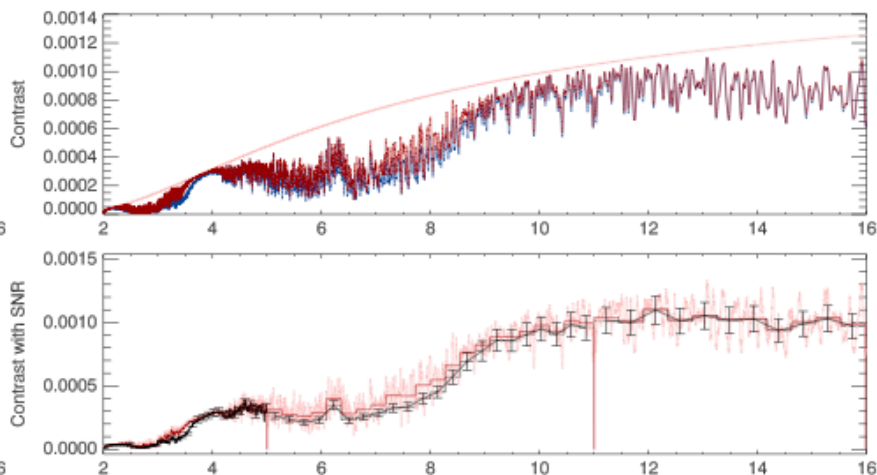
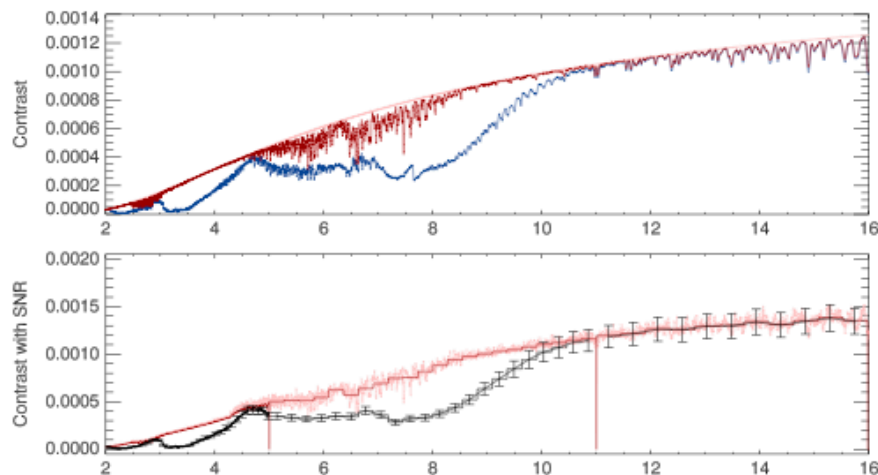
R=20 @ $\lambda > 5 \mu m$

SNR	H_2O		CO_2	NH_3		O_3	
	5 - 8 μm	11 - 16 μm	15 μm	6 μm	11 μm	9.6 μm	14.3 μm
10	10^{-6}	10^{-4}	10^{-6}	10^{-6}	10^{-6}	10^{-7}	10^{-5}
5	10^{-6}	10^{-4}	10^{-6}	10^{-5}	10^{-6}	10^{-7}	10^{-5}

Warm Neptune in wet atmosphere

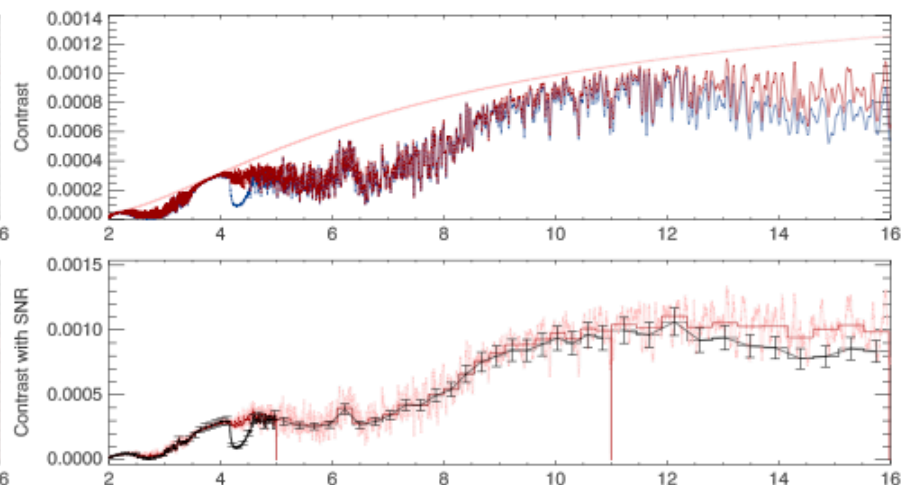
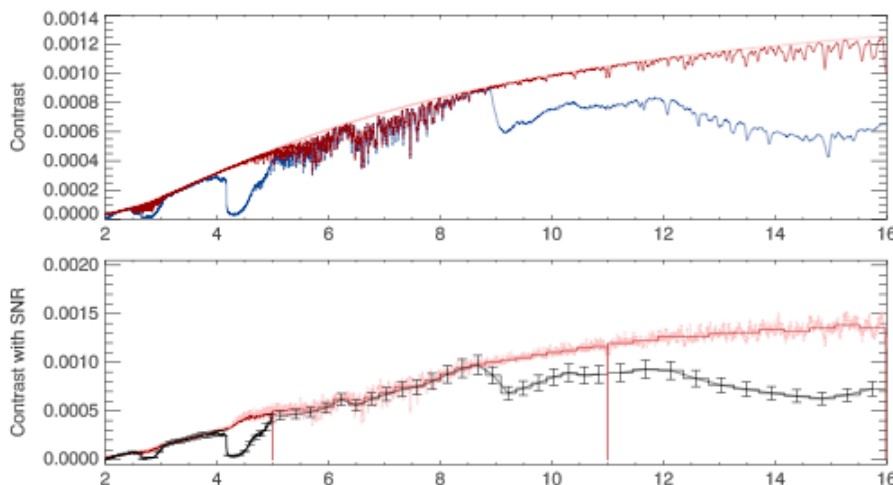
H₂O @ 1e-6 CH₄ @ 1e-4

H₂O @ 1e-4 CH₄ @ 1e-6



H₂O @ 1e-6 CO₂ @ 1e-4

H₂O @ 1e-4 CO₂ @ 1e-6



Warm Neptune in wet atmosphere

SNR=5

H_2O	CH_4		CO		CO_2			NH_3		
	$3.3 \mu m$	$8 \mu m$	$2.3 \mu m$	$4.6 \mu m$	$2.8 \mu m$	$4.3 \mu m$	$15 \mu m$	$3 \mu m$	$6.1 \mu m$	$10.5 \mu m$
θ	10^{-7}	10^{-5}	10^{-3}	10^{-4}	10^{-6}	10^{-7}	10^{-5}	10^{-6}	10^{-5}	10^{-5}
10^{-7}	10^{-7}	10^{-5}	10^{-3}	10^{-4}	10^{-6}	10^{-7}	10^{-5}	10^{-5}	10^{-5}	10^{-5}
10^{-6}	10^{-7}	10^{-5}	10^{-3}	10^{-4}	10^{-6}	10^{-7}	10^{-5}	10^{-5}	10^{-5}	10^{-5}
10^{-5}	10^{-7}	10^{-5}	10^{-3}	10^{-4}	10^{-7}	10^{-7}	10^{-5}	10^{-5}	10^{-5}	10^{-5}
10^{-4}	10^{-7}	10^{-4}	10^{-7}	10^{-4}	10^{-7}	10^{-7}	10^{-4}	10^{-7}	10^{-4}	10^{-4}
10^{-3}	10^{-7}	10^{-3}	10^{-7}	10^{-4}	10^{-7}	10^{-7}	—	10^{-7}	10^{-3}	10^{-4}

SNR=10

H_2O	CH_4		CO		CO_2			NH_3		
	$3.3 \mu m$	$8 \mu m$	$2.3 \mu m$	$4.6 \mu m$	$2.8 \mu m$	$4.3 \mu m$	$15 \mu m$	$3 \mu m$	$6.1 \mu m$	$10.5 \mu m$
θ	10^{-7}	10^{-6}	10^{-3}	10^{-5}	10^{-6}	10^{-7}	10^{-6}	10^{-6}	10^{-6}	10^{-6}
10^{-7}	10^{-7}	10^{-6}	10^{-3}	10^{-5}	10^{-6}	10^{-7}	10^{-6}	10^{-6}	10^{-6}	10^{-6}
10^{-6}	10^{-7}	10^{-6}	10^{-3}	10^{-5}	10^{-7}	10^{-7}	10^{-6}	10^{-6}	10^{-6}	10^{-6}
10^{-5}	10^{-7}	10^{-6}	10^{-7}	10^{-5}	10^{-7}	10^{-7}	10^{-6}	10^{-7}	10^{-5}	10^{-6}
10^{-4}	10^{-7}	10^{-6}	10^{-7}	10^{-5}	10^{-7}	10^{-7}	10^{-5}	10^{-7}	10^{-5}	10^{-5}
10^{-3}	10^{-7}	10^{-5}	10^{-7}	10^{-5}	10^{-7}	10^{-7}	10^{-4}	10^{-7}	10^{-5}	10^{-5}

Warm Neptune in wet atmosphere

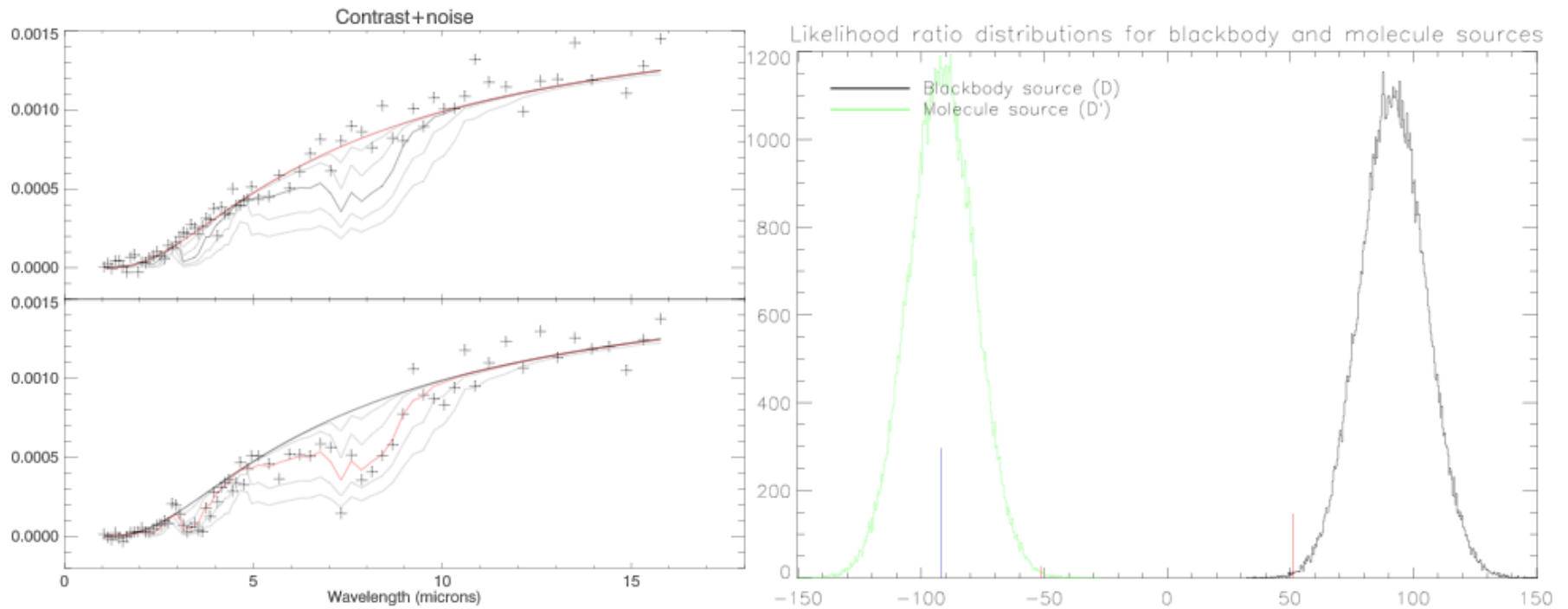
SNR=5

H_2O	CH_4		CO		CO_2			NH_3		
	$3.3 \mu m$	$8 \mu m$	$2.3 \mu m$	$4.6 \mu m$	$2.8 \mu m$	$4.3 \mu m$	$15 \mu m$	$3 \mu m$	$6.1 \mu m$	$10.5 \mu m$
0	10^{-7}	10^{-5}	10^{-3}	10^{-4}	10^{-6}	10^{-7}	10^{-5}	10^{-6}	10^{-5}	10^{-5}
10^{-7}	10^{-7}	10^{-5}	10^{-3}	10^{-4}	10^{-6}	10^{-7}	10^{-5}	10^{-5}	10^{-5}	10^{-5}
10^{-6}	10^{-7}	10^{-5}	10^{-3}	10^{-4}	10^{-6}	10^{-7}	10^{-5}	10^{-5}	10^{-5}	10^{-5}
10^{-5}	10^{-7}	10^{-5}	10^{-3}	10^{-4}	10^{-7}	10^{-7}	10^{-5}	10^{-5}	10^{-5}	10^{-5}
10^{-4}	10^{-7}	10^{-4}	10^{-7}	10^{-4}	10^{-7}	10^{-7}	10^{-4}	10^{-7}	10^{-4}	10^{-4}
10^{-3}	10^{-7}	10^{-3}	10^{-7}	10^{-4}	10^{-7}	10^{-7}	—	10^{-7}	10^{-3}	10^{-4}

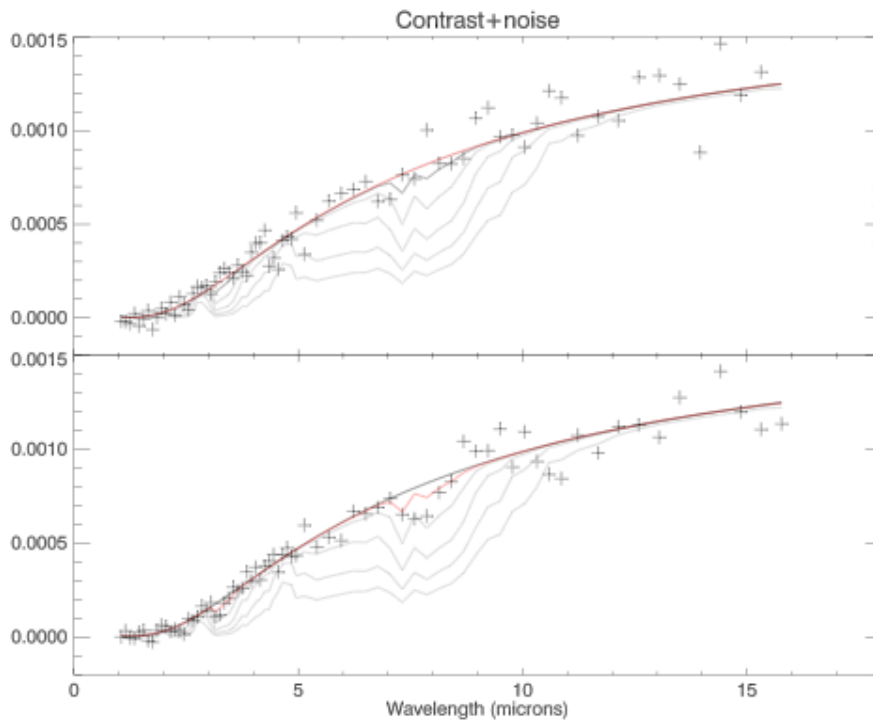
SNR=10

H_2O	CH_4		CO		CO_2			NH_3		
	$3.3 \mu m$	$8 \mu m$	$2.3 \mu m$	$4.6 \mu m$	$2.8 \mu m$	$4.3 \mu m$	$15 \mu m$	$3 \mu m$	$6.1 \mu m$	$10.5 \mu m$
0	10^{-7}	10^{-6}	10^{-3}	10^{-5}	10^{-6}	10^{-7}	10^{-6}	10^{-6}	10^{-6}	10^{-6}
10^{-7}	10^{-7}	10^{-6}	10^{-3}	10^{-5}	10^{-6}	10^{-7}	10^{-6}	10^{-6}	10^{-6}	10^{-6}
10^{-6}	10^{-7}	10^{-6}	10^{-3}	10^{-5}	10^{-7}	10^{-7}	10^{-6}	10^{-6}	10^{-6}	10^{-6}
10^{-5}	10^{-7}	10^{-6}	10^{-7}	10^{-5}	10^{-7}	10^{-7}	10^{-6}	10^{-7}	10^{-5}	10^{-6}
10^{-4}	10^{-7}	10^{-6}	10^{-7}	10^{-5}	10^{-7}	10^{-7}	10^{-5}	10^{-7}	10^{-5}	10^{-5}
10^{-3}	10^{-7}	10^{-5}	10^{-7}	10^{-5}	10^{-7}	10^{-7}	10^{-4}	10^{-7}	10^{-5}	10^{-5}

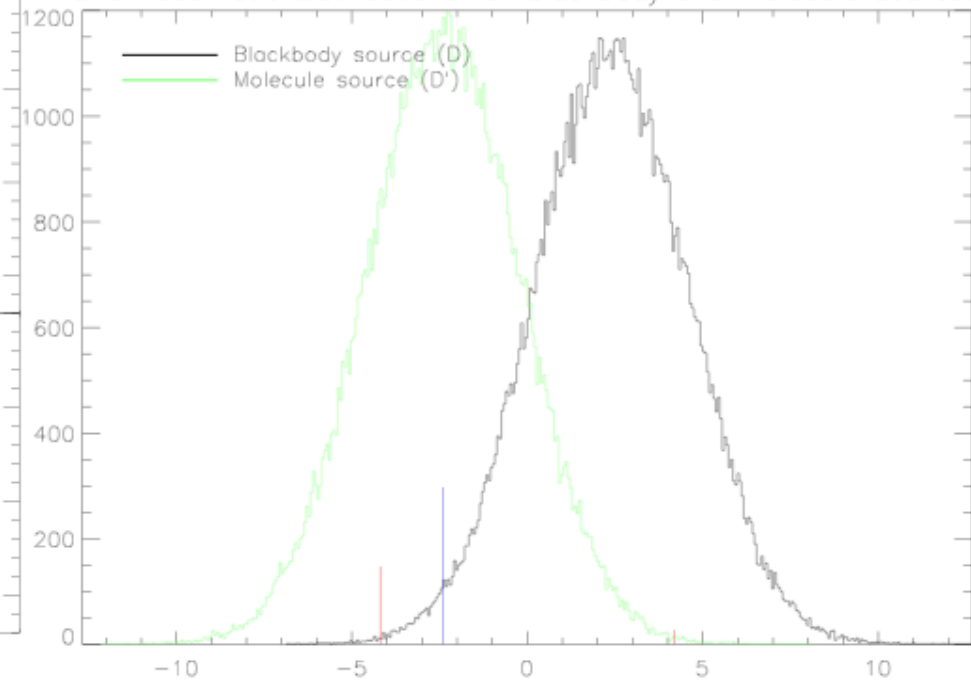
Likelihood ratio test: Warm Neptune with CH₄



Likelihood ratio test: Warm Neptune with CH₄



Likelihood ratio distributions for blackbody and molecule sources



LR compared to individual bin detection

Warm Neptune at 13.5pc, 1 transit										
Method	PH_3	CO	CO_2	CH_4	NH_3	HCN	C_2H_2	C_2H_6	H_2S	H_2O
Individual bins	10^{-5}	10^{-3}	10^{-5}	10^{-5}	10^{-5}	10^{-5}	10^{-5}	10^{-5}	10^{-3}	10^{-5}
LRT	10^{-6}	10^{-4}	10^{-7}	10^{-6}	10^{-6}	10^{-6}	10^{-6}	10^{-5}	10^{-3}	10^{-6}
Hot Jupiter at 150pc, 1 transit										
Method	PH_3	CO	CO_2	CH_4	NH_3	HCN	C_2H_2	C_2H_6	H_2S	H_2O
Individual bins	10^{-5}	10^{-4}	10^{-6}	10^{-5}	10^{-5}	10^{-5}	10^{-5}	10^{-4}	–	10^{-5}
LRT	10^{-6}	10^{-5}	10^{-7}	10^{-6}	10^{-6}	10^{-6}	10^{-6}	10^{-5}	10^{-4}	10^{-6}
Temperate super-Earth at 6pc, 200 transits										
Method	H_2O	CO_2	NH_3	O_3^*						
Individual bins	10^{-4}	10^{-6}	10^{-5}	10^{-7}						
LRT	10^{-5}	10^{-6}	10^{-6}	10^{-6}						

SNR 5 typically enough for detection!

CH_4									CO	
SNR	$3 \mu m$								$4.6 \mu m$	
20	10^{-6}									
10	10^{-6}									
5										

	H_2O		CO_2	CH_4	C_2H_2		C_2H_6
SNR	$5 - 8 \mu m$	$11 - 16 \mu m$	$15 \mu m$	$8 \mu m$	$7.5 \mu m$	$13.7 \mu m$	$12.2 \mu m$
20	10^{-6}	10^{-5}	10^{-7}	10^{-7}	10^{-6}	10^{-7}	10^{-6}
10	10^{-6}	10^{-4}	10^{-7}	10^{-7}	10^{-5}	10^{-6}	10^{-6}
5	10^{-5}	10^{-3}	10^{-7}	10^{-6}	10^{-4}	10^{-5}	10^{-5}

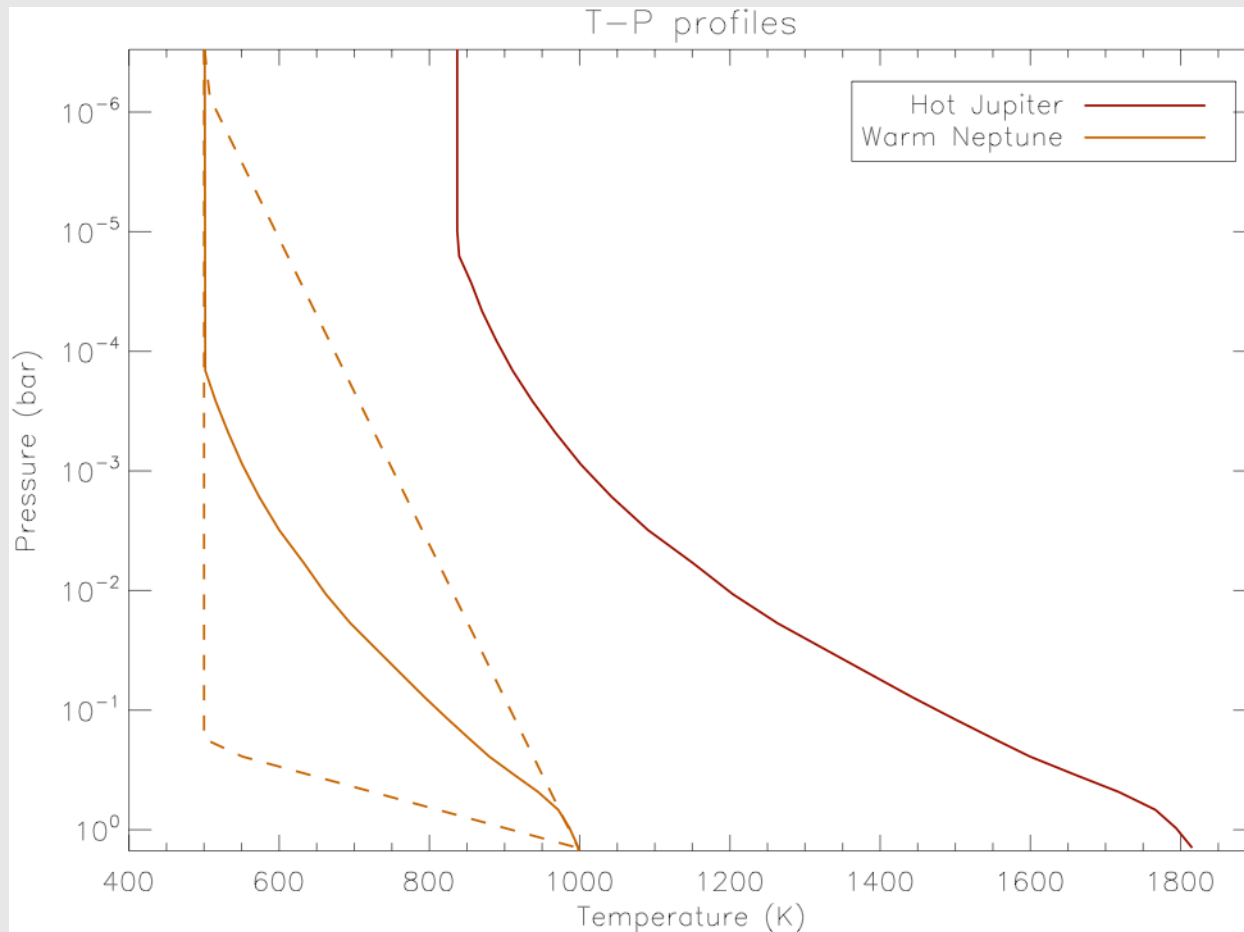
5	10^{-4}	10^{-6}	10^{-4}	10^{-6}	10^{-5}	10^{-6}	10^{-7}	10^{-5}
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	C_2H_6		H_2S			C_2H_2		
SNR	$3.3 \mu m$	$12.2 \mu m$	$2.6 \mu m$	$4.25 \mu m$	$8 \mu m$	$3 \mu m$	$7.5 \mu m$	$13.7 \mu m$
20	10^{-4}	10^{-5}	10^{-4}	10^{-3}	-	10^{-7}	10^{-3}	10^{-4}
10	10^{-4}	10^{-4}	10^{-4}	10^{-3}	-	10^{-6}	10^{-3}	10^{-4}
5	10^{-3}	10^{-3}	10^{-3}	-	-	10^{-6}	-	10^{-4}

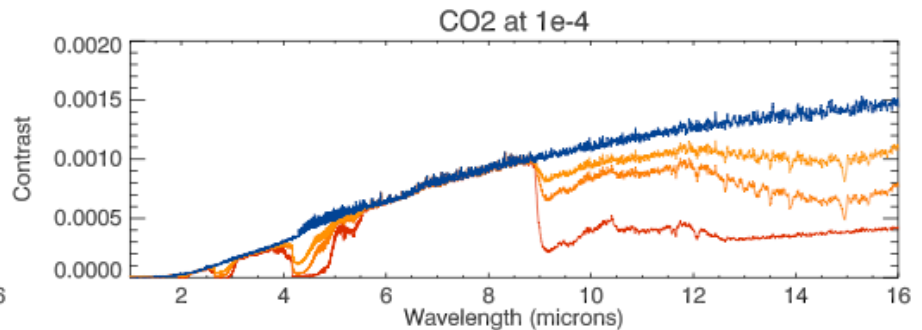
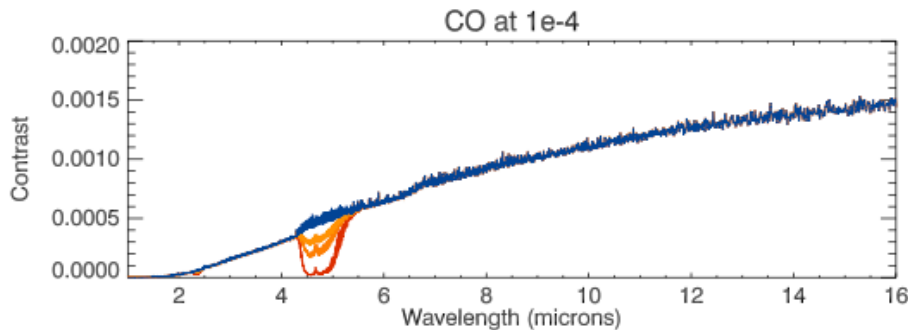
5	10^{-5}	10^{-5}	10^{-4}
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Alternative thermal profile

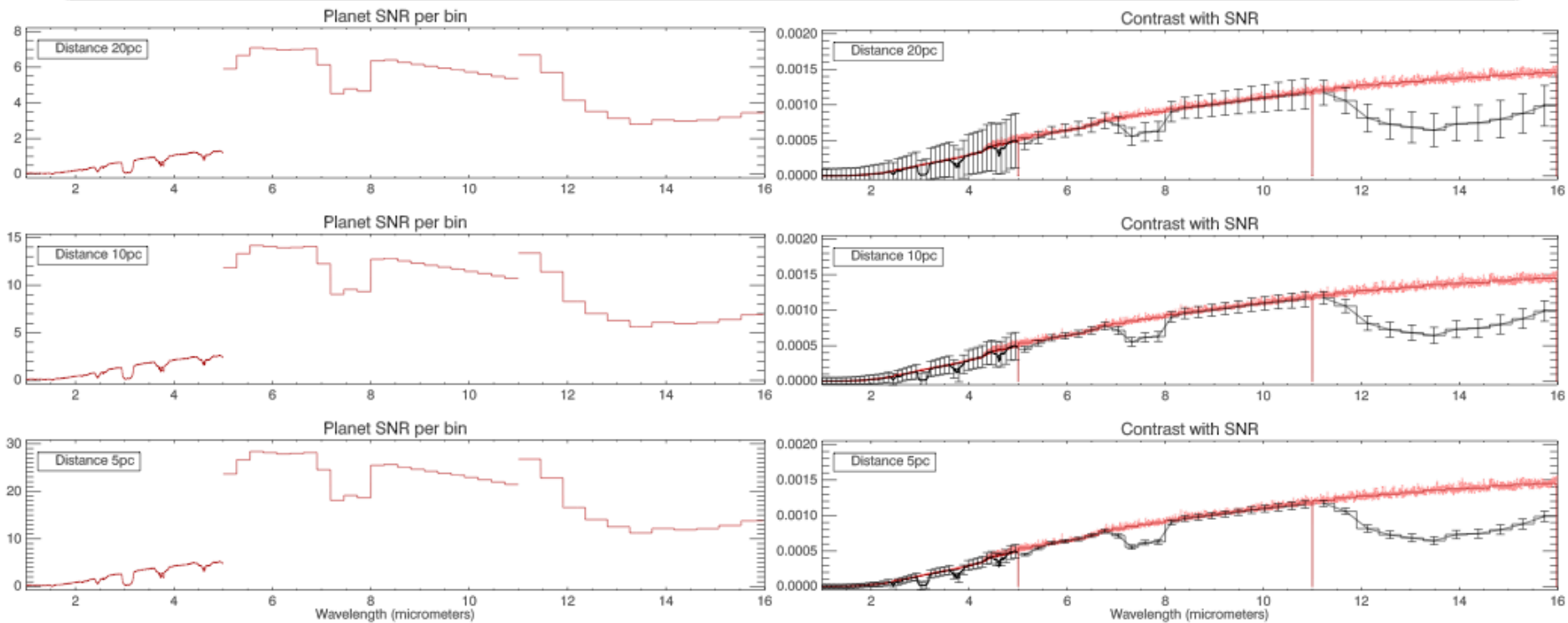


Alternative thermal profile



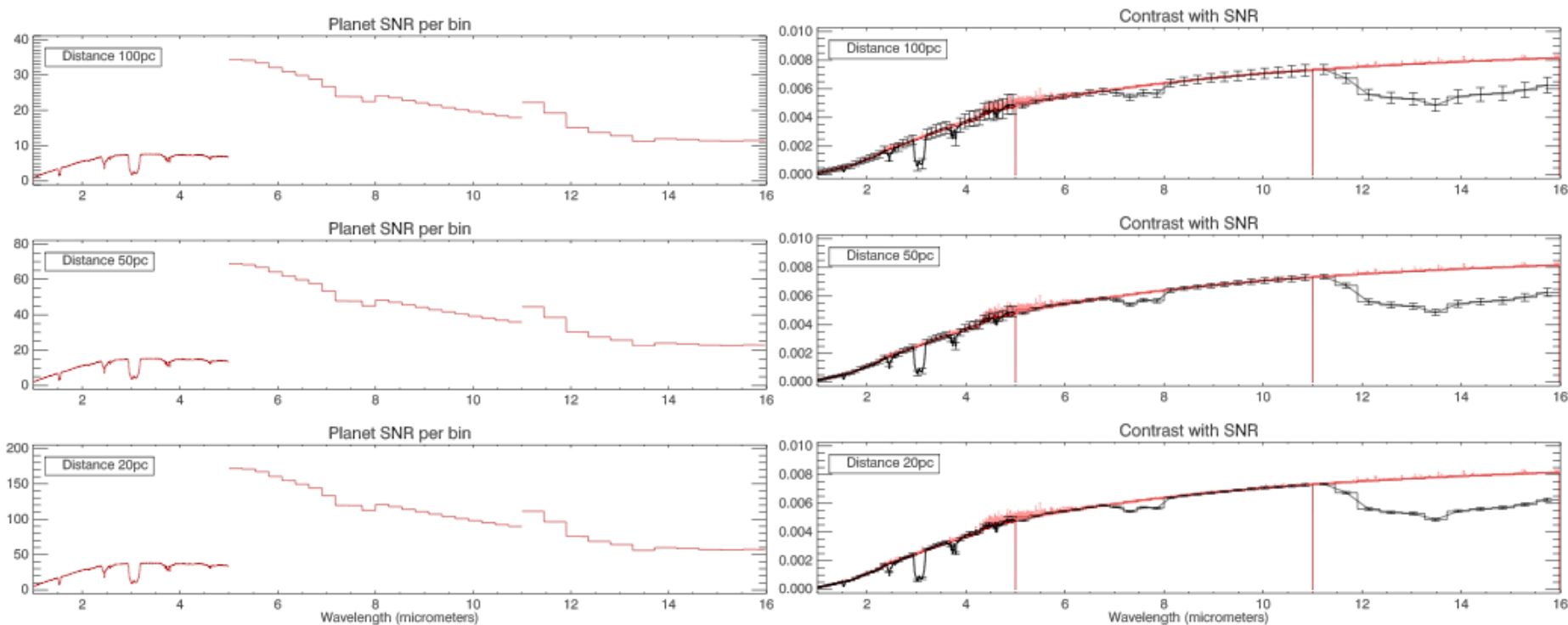
SNR	<i>CO</i>		<i>CO₂</i>		
	2.3 μm	4.6 μm	2.8 μm	4.3 μm	15 μm
20	$10^{-(4/4/5)}$	$10^{-(5/6/6)}$	$10^{-(7/7/7)}$	$10^{-(7/7/7)}$	$10^{-(6/7/7)}$
10	$10^{-(3/3/4)}$	$10^{-(4/5/6)}$	$10^{-(6/6/7)}$	$10^{-(7/7/7)}$	$10^{-(5/6/7)}$
5	$10^{-(2/3/4)}$	$10^{-(3/4/6)}$	$10^{-(5/6/7)}$	$10^{-(6/7/7)}$	$10^{-(3/5/7)}$

Results with EChO



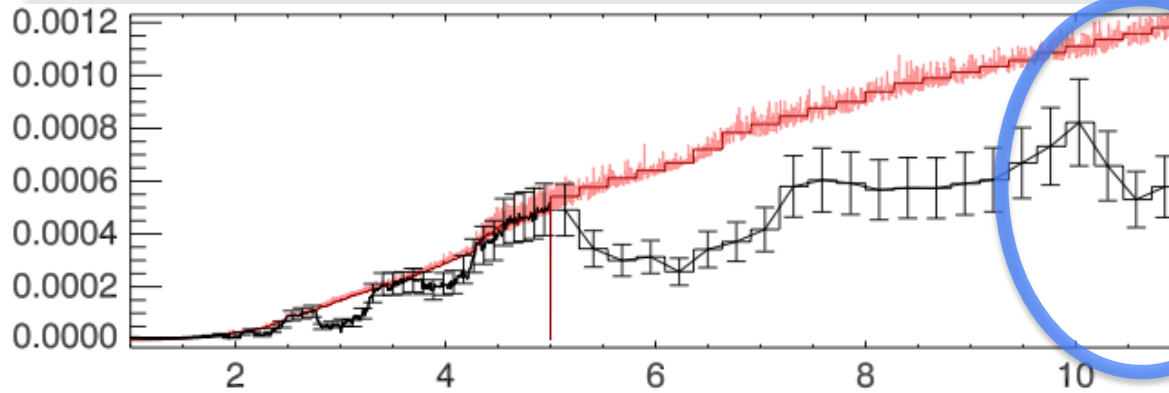
Warm Neptune with C_2H_2 in the atmosphere (mixing ratio = 10^{-4})
 1 transit

Results with EChO

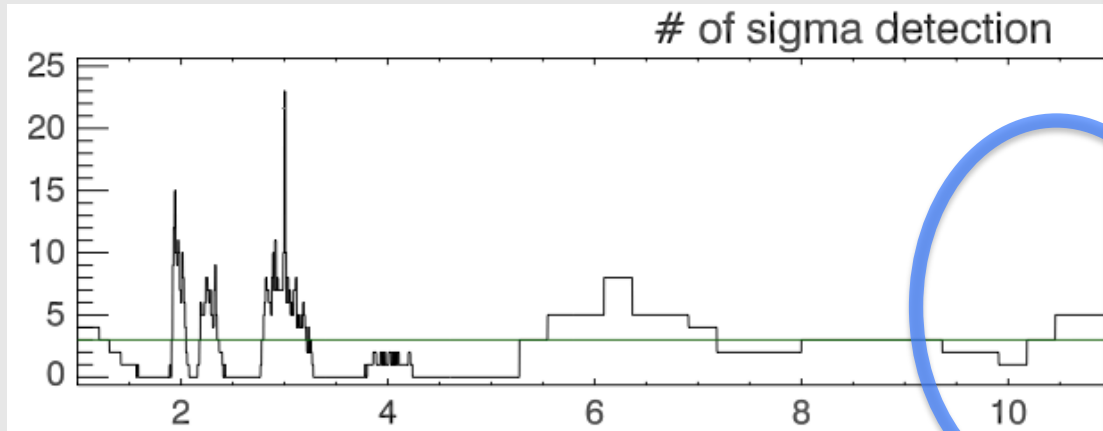


Hot Jupiter with C_2H_2 in the atmosphere (mixing ratio = 10^{-4})
 1 transit

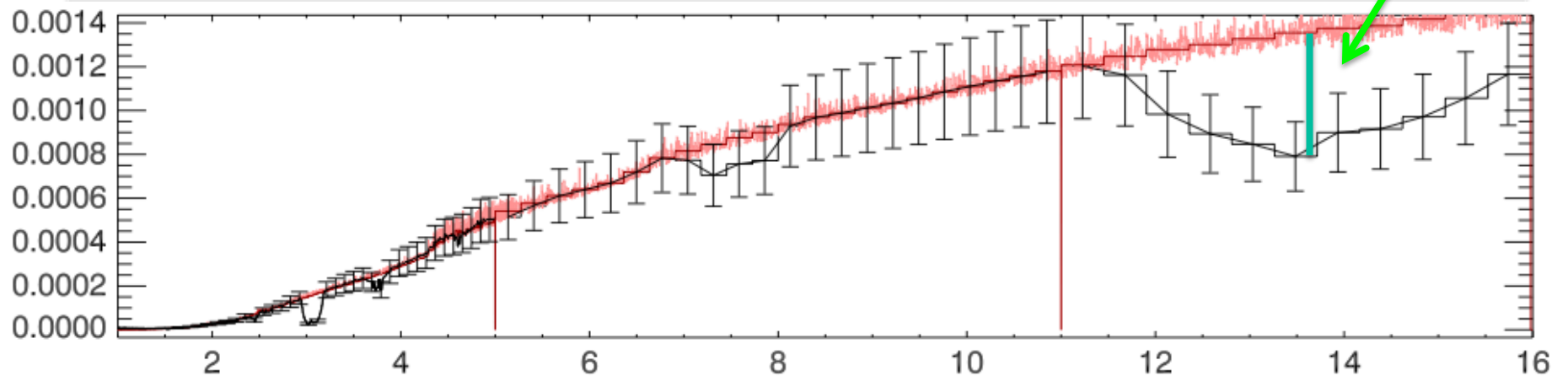
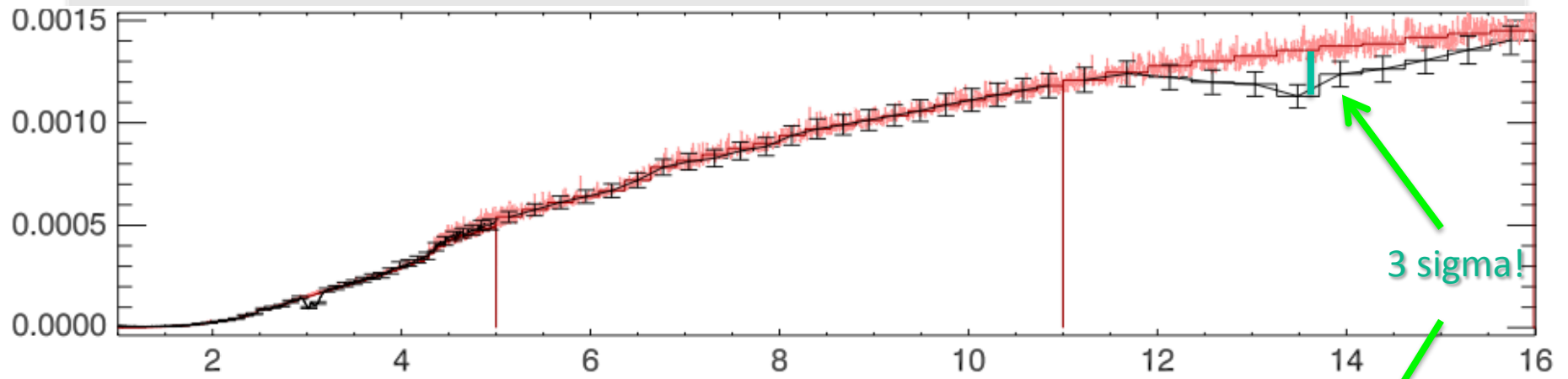
Warm Neptune, NH₃ at 1e-4 @ SNR = 5



Between 10 and 11 μ m,
multiple bins



Detectability – separated from instrument



Key Molecules (transmission)

