HARP – Actinic Flux in the near-infrared

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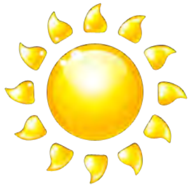
Topics

- UV/VIS/NIR Actinic flux measurements
- Calibration update
- Spectral vs jNO2 photolysis frequencies

HARP – Actinic Flux: UV/VIS/NIR measurements

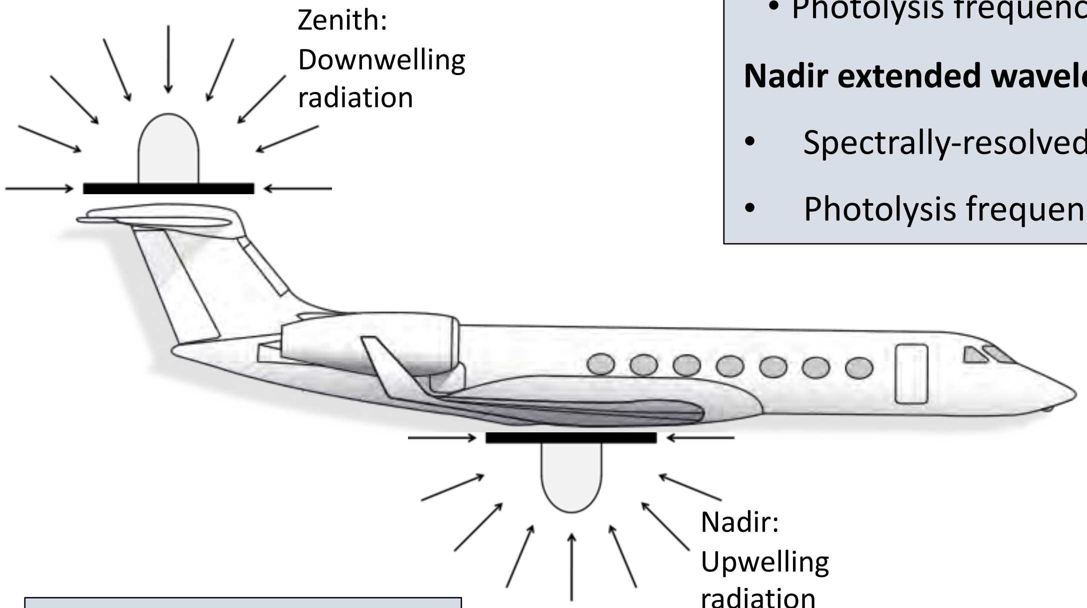


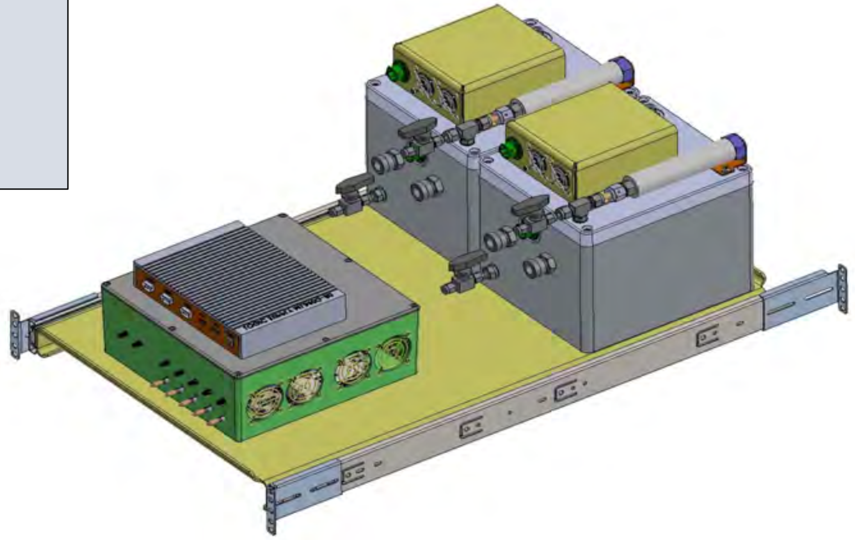
Zenith spectrometer

- Spectrally-resolved (280-650 nm)
- Photolysis frequencies

Nadir extended wavelength spectrometer

- Spectrally-resolved (280-1000 nm)
- Photolysis frequencies and ???

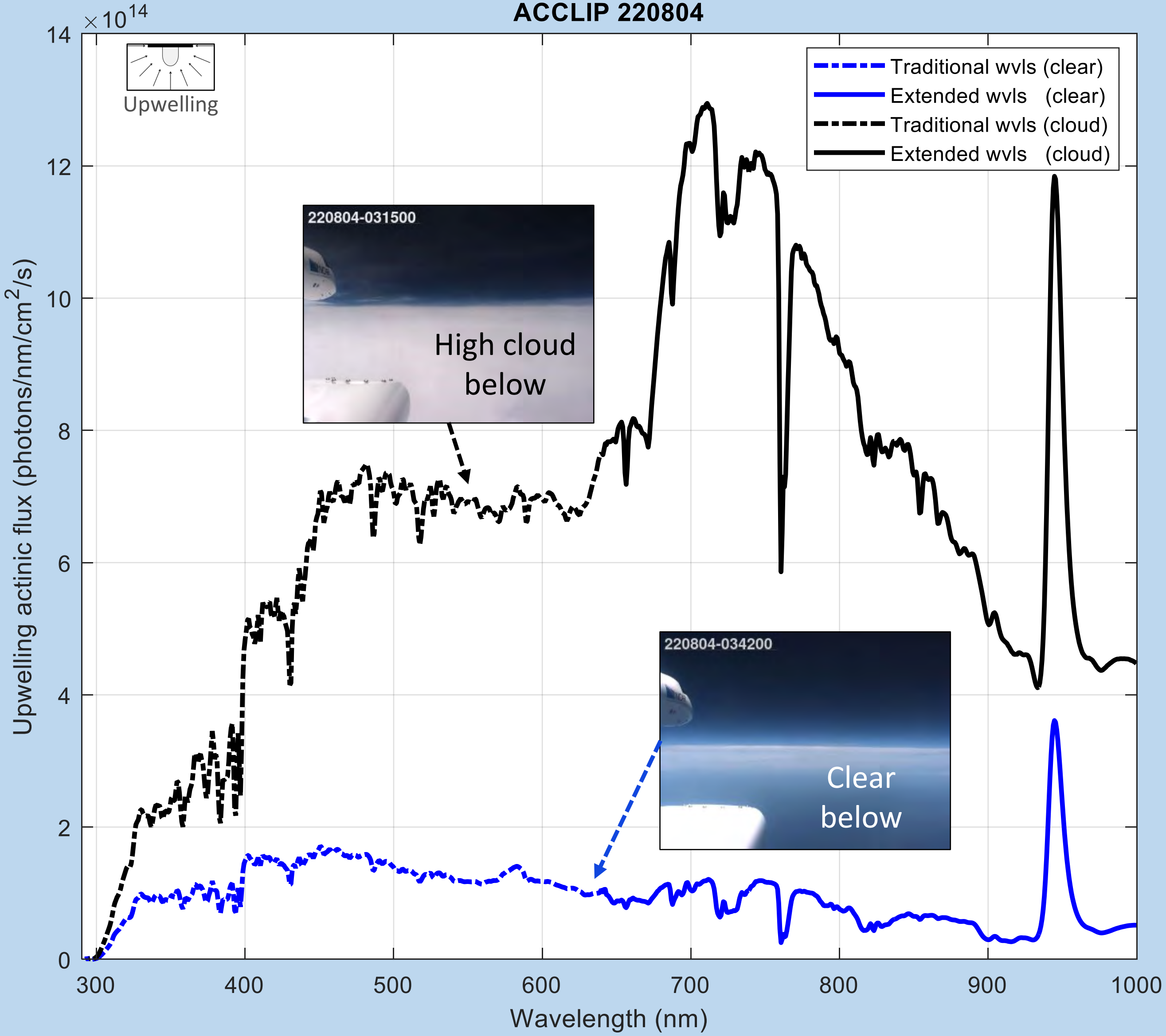




Photolysis frequencies

j [O3->O2+O(1D)]	*j* [CH3CHO->CH4+CO]	*j* [CH3ONO2-> CH3O+NO2]	*j* [CH3CH2ONO2-> Products]	*j* [BrONO2->Br+NO3]
j [NO2->NO+O(3P)]	*j* [C2H5CHO-> C2H5+HCO]	*j* [CH3COCH2CH3-> Products]	*j* [Br2->Br+Br]	*j* [BrONO2->BrO+NO2]
j [H2O2->2OH]	*j* [CHOCHO->products]	*j* [CH3CH2CH2CHO-> C3H7+HCO]	*j* [BrO->Br+O]	*j* [Cl2+hv->Cl+Cl]
j [HNO2->OH+NO]	*j* [CHOCHO->HCO+HCO]		*j* [Br2O->products]	*j* [ClO->Cl+O]
j [HNO3->OH+NO2]	*j* [PAN->products]	*j* [CH3CH2CH2CHO-> C2H4+CH2CHOH]	*j* [BrNO3->Br+NO3]	*j* [ClONO2->Cl+NO3]
j [CH2O->H+HCO]	*j* [CH3COCHO-> products]		*j* [BrNO3->BrO+NO2]	*j* [ClONO2->ClO+NO2]
j [CH2O->H2+CO]	*j* [CH3COCH3-> CH3CO+CH3]	*j* [HO2NO2-->HO2+NO2]*	*j* [BrCl->Br+Cl]	*j* [ClNO2->Cl+NO2]
j [CH3CHO->CH3+HCO]	*j* [CH3OOH->CH3O+OH]	*j* [HO2NO2->OH+NO3]*	*j* [HOBr->HO+Br]	*j* [CHBr3->Products]

HARP – Actinic Flux: UV/VIS/NIR measurements



Spectral features

- Cloud enhances all wavelengths
- 300-600 nm (traditional wvls) well-calibrated

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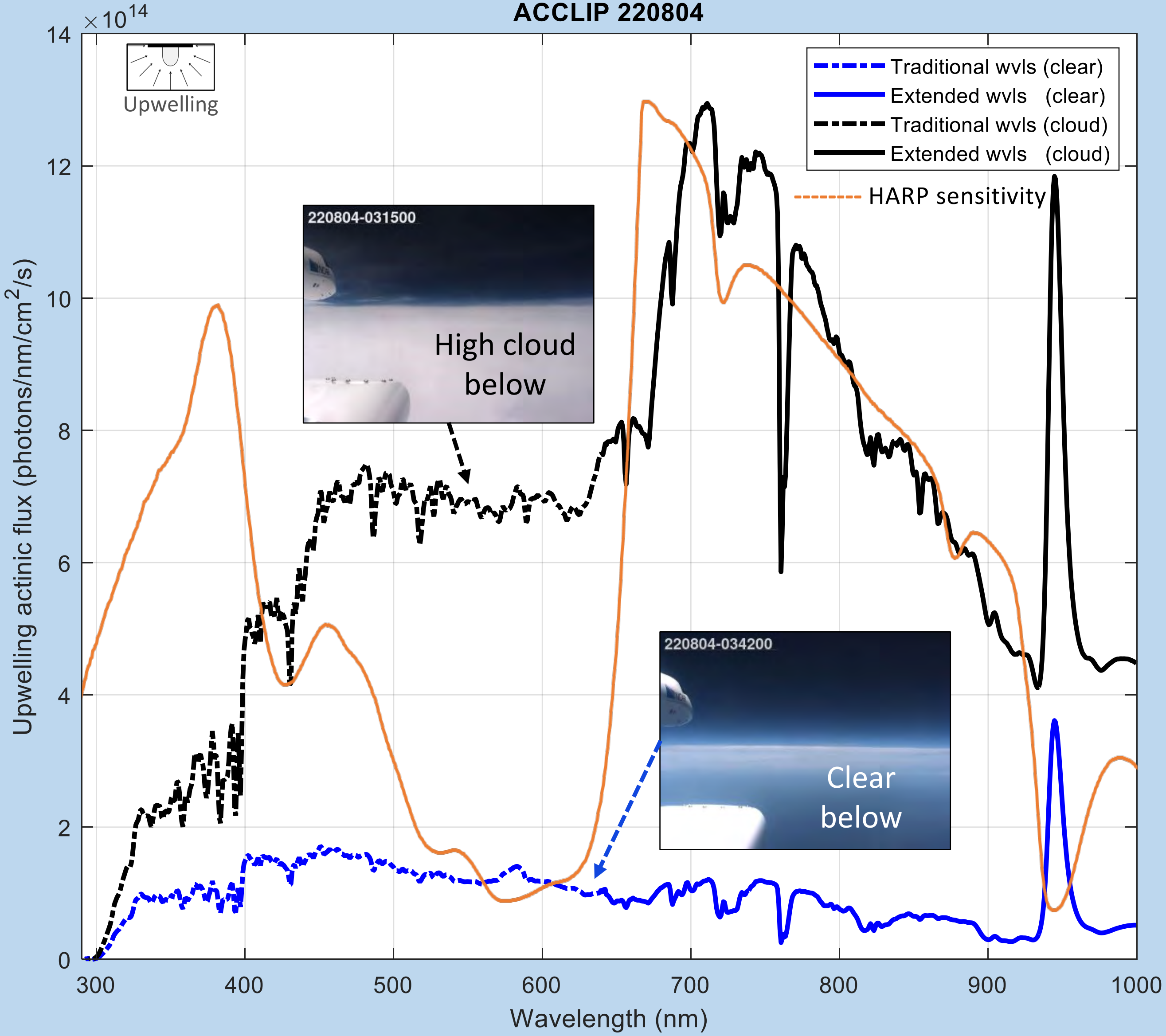

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Sensitivity issues to be examined

- 650-820 nm enhancement appears non-physical. Overlaps with sharp UG5 filter features.
- 950 nm calibrations (and/or data) are below LOD resulting in false local enhancement

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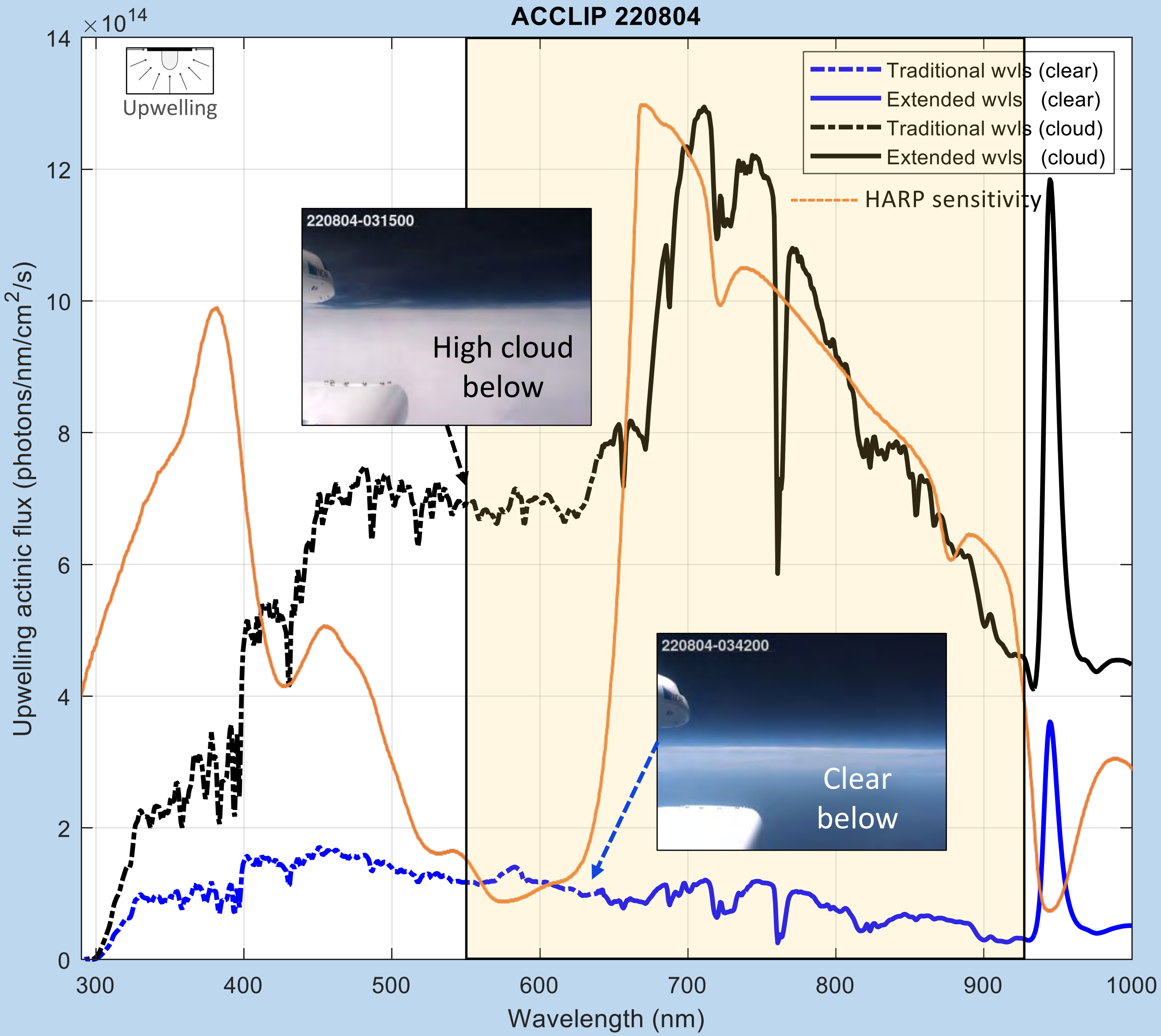

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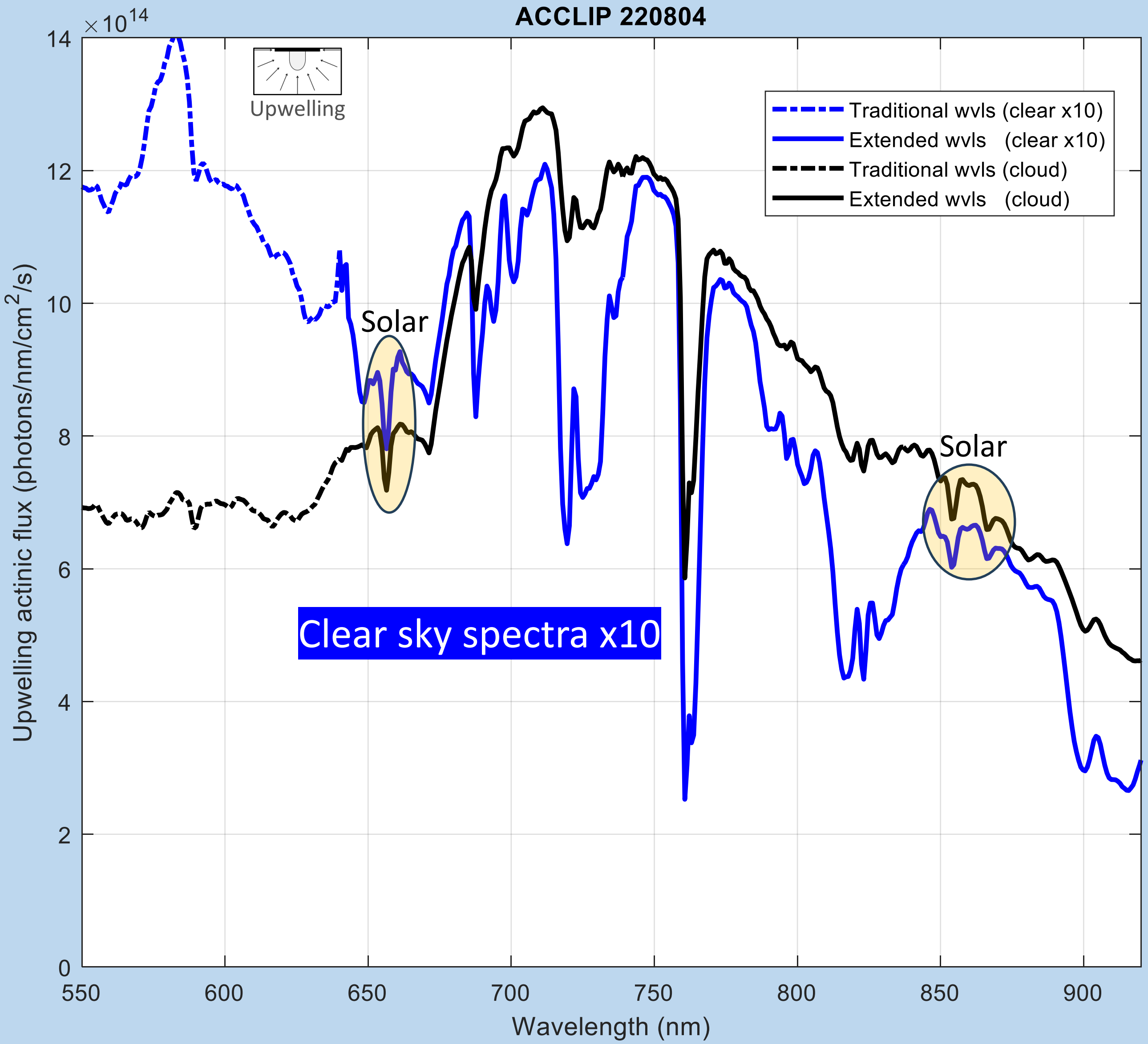
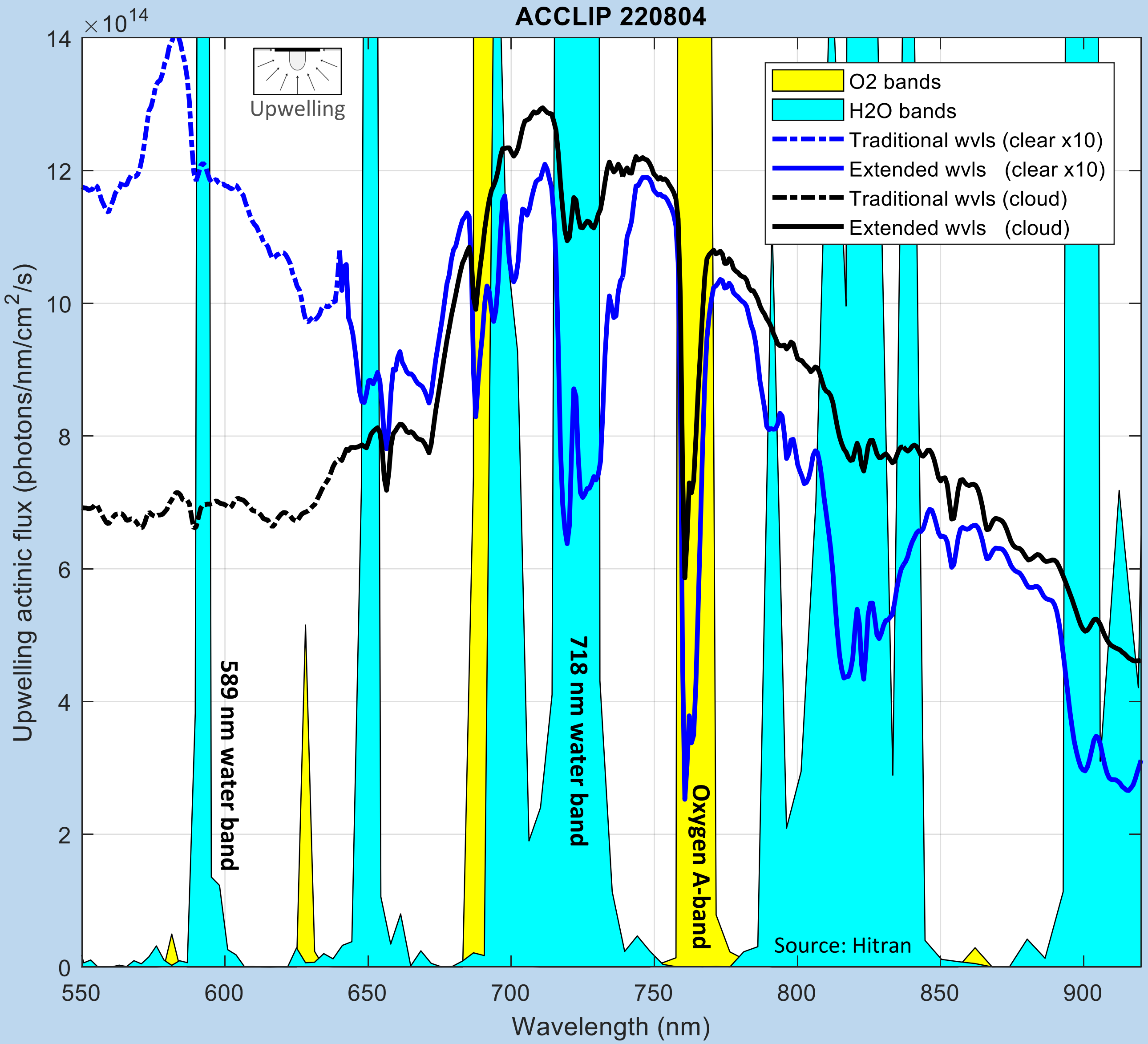


Relative comparisons

- Solar absorption features are similar in magnitude
- Clear-sky absorption features are generally deeper than with cloud below

HARP – Actinic Flux: UV/VIS/NIR measurements



Water vapor in the atmosphere

- Highly variable
- Absorption a function of humidity profile

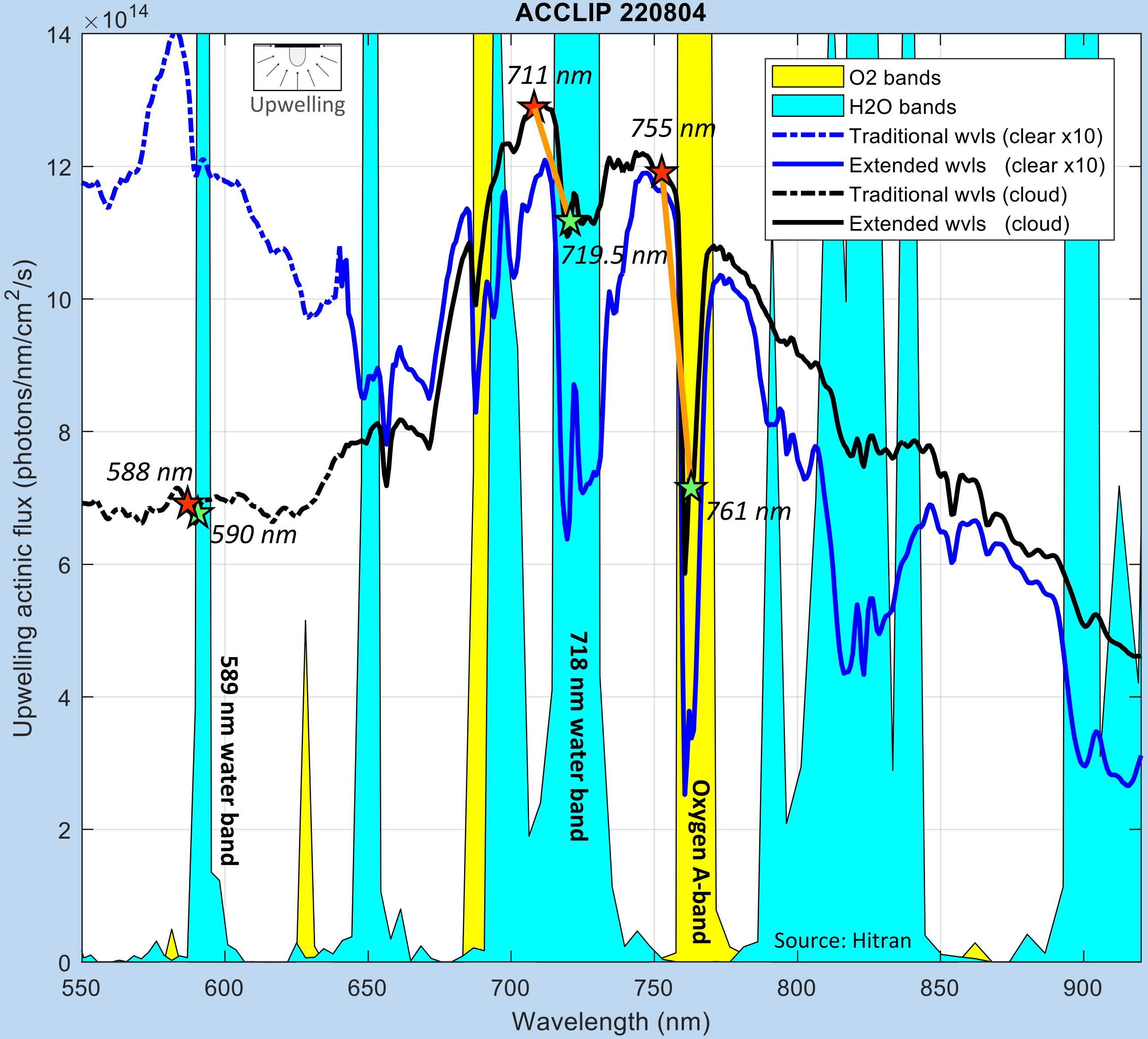
Oxygen in the atmosphere

- Low variability
- Absorption a function of air density
- Oxygen absorption represents a pathlength weighted by air density

Cloud vs clear comparisons

- Clouds ≠ water vapor
- Clouds below scatter light from above
  - Thus, the pathlength is reduced and absorption is restricted
- Clear-sky allows a longer pathlength
  - Down and up
  - Higher density air below (more H_2O and O_2)
  - Thus, total absorption increased

HARP – Actinic Flux: UV/VIS/NIR measurements



Compare on/off line

- On-line near peak absorption (spectro dependent)
- Off-line isolated from spectral features
- 589 nm water band is very weak but available in past data sets for up and downwelling

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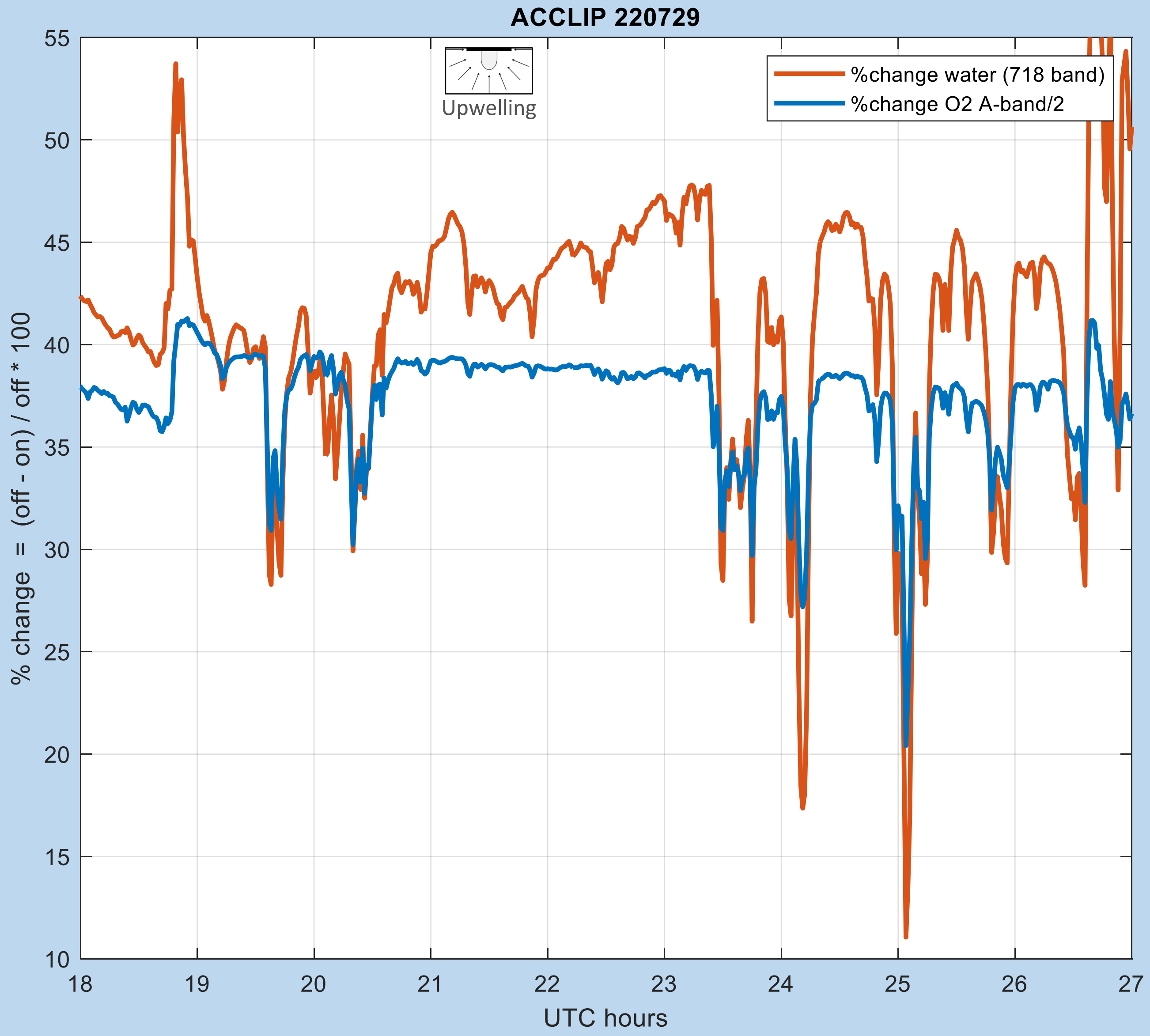

Percent change in signal from absorption features

- Kona – Guam (significant water vapor variability)

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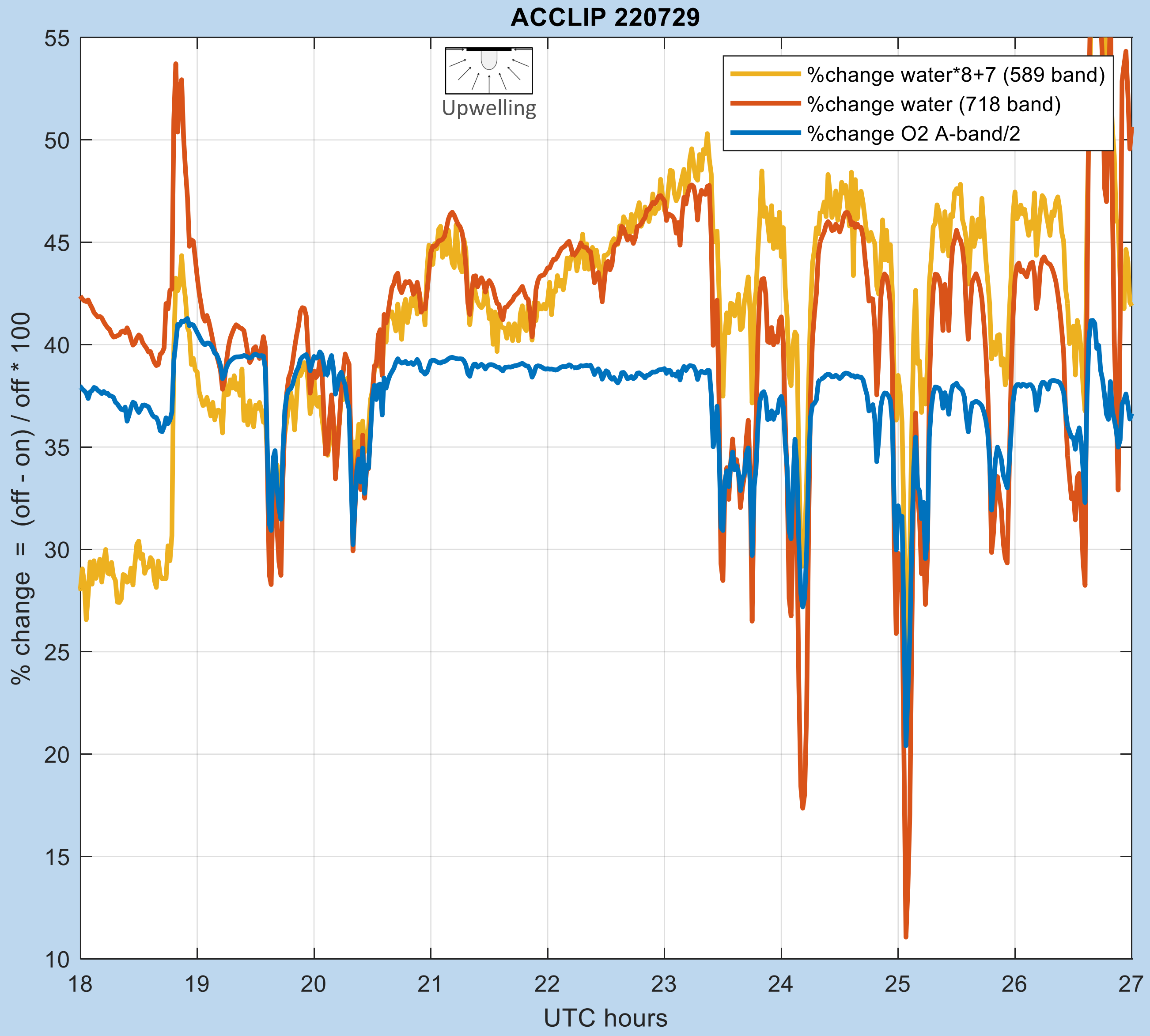
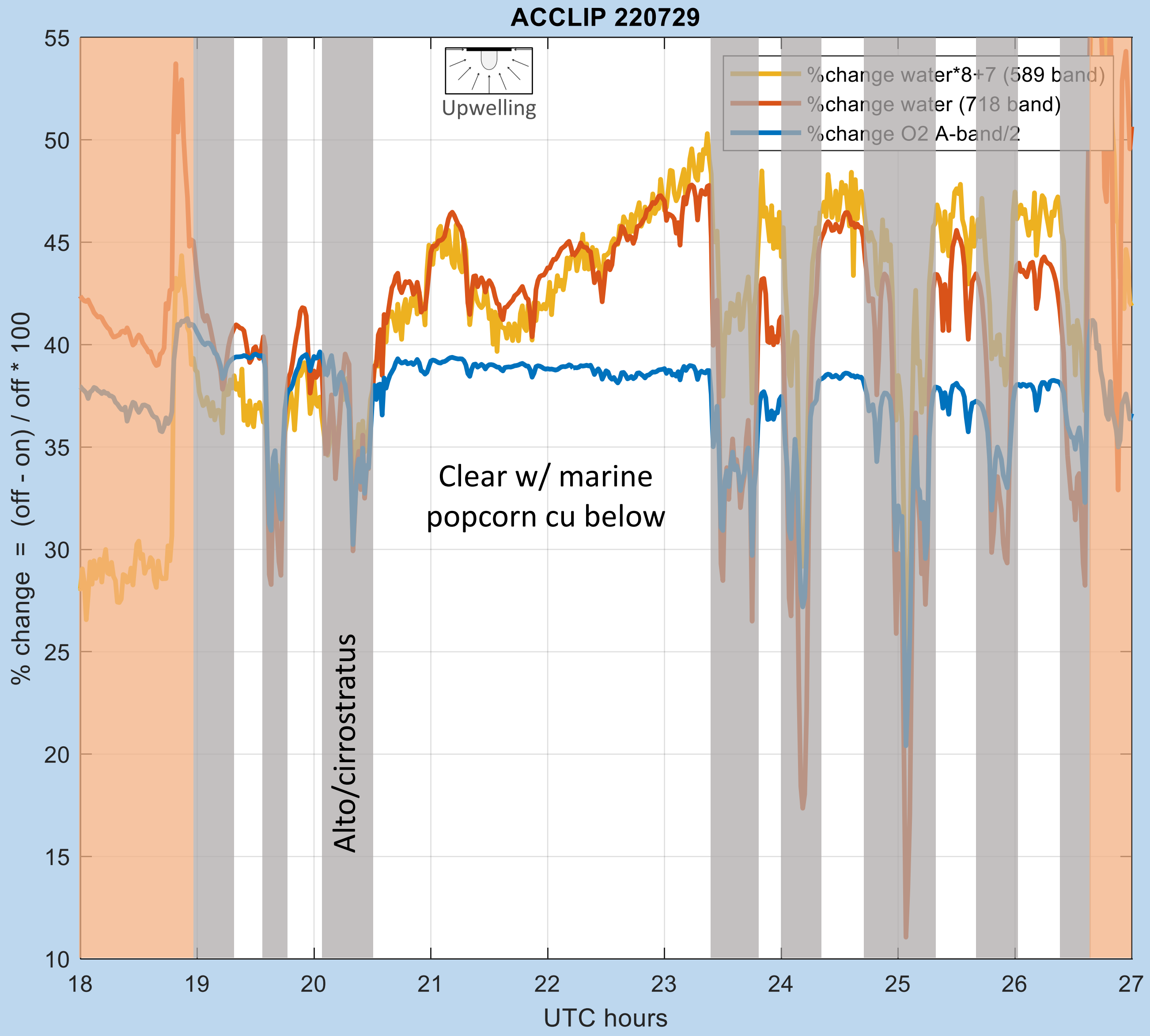


Percent change in signal from absorption features

- Kona – Guam (significant water vapor variability)
- Water bands (strong 718 nm and weak 589 nm) show similar features

HARP – Actinic Flux: UV/VIS/NIR measurements



Notable features

- High clouds decrease pathlength resulting in reduced absorption
- Takeoff and landing show enhanced absorption (multiscattering between clouds?)
- Oxygen A-band is nearly flat (20:30-23:30)
  - Cloud-free below so (nearly) constant pathlength
  - Water vapor absorption structure
- Oxygen A-band absorption decreases slowly with time
  - Tracks sun rising from from 55˚ to 4˚ SZA
  - Higher sun = shorter pathlength

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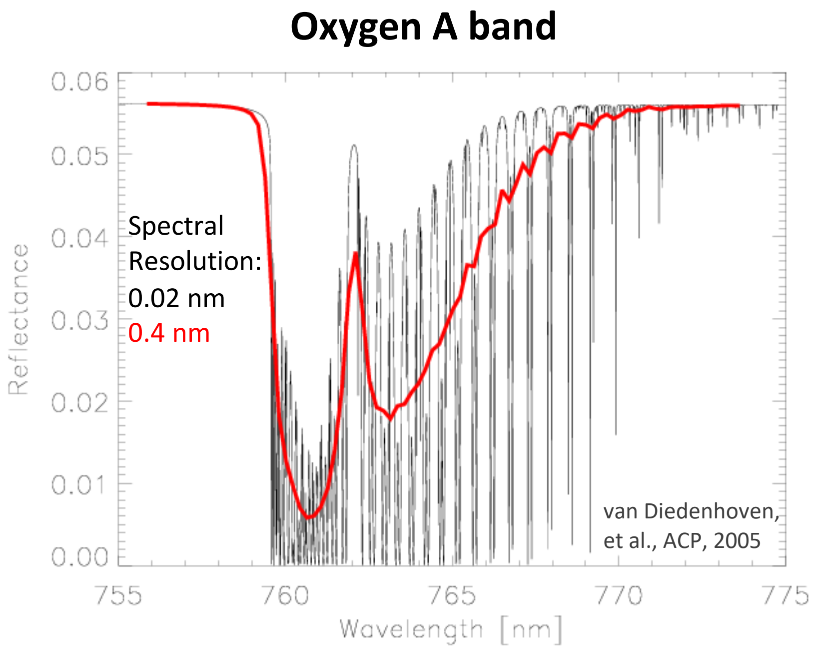
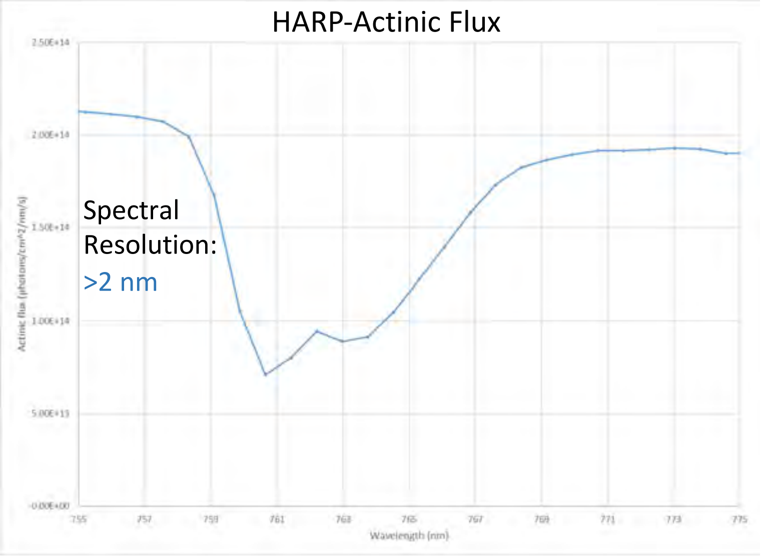




Limitations

- **Non-pointing actinic flux**
- **Low spectral resolution**
- Limited characterization of wavelengths and power
- Filter transmission sensitivity
- Very low sensitivity at 950 nm
- Sensitive to attitude changes (requires level flight)
- QuickTUV does not include O2 or water absorption

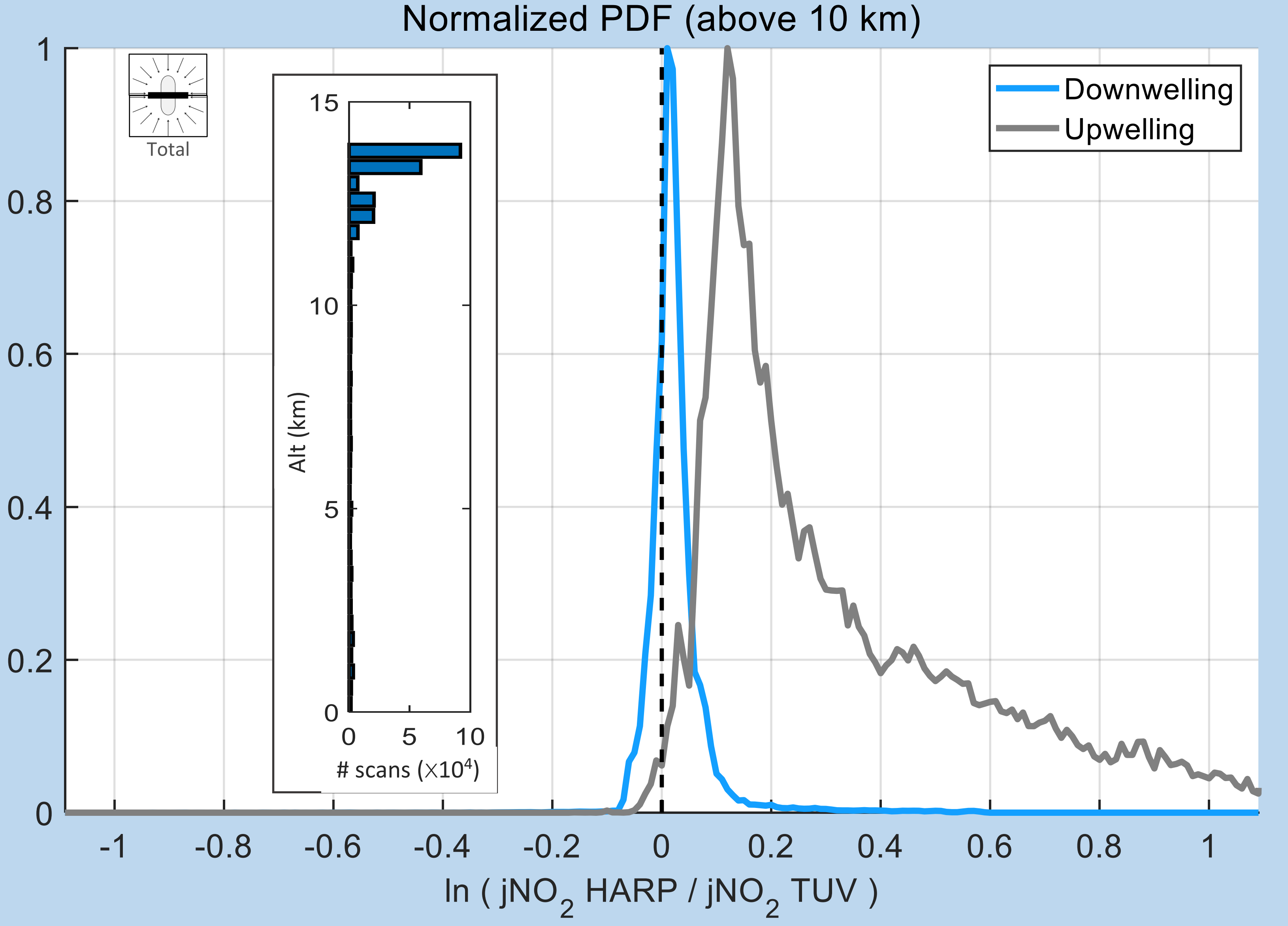
Retrieval examples

- **Cloud detection**
- **Water vapor profile (relative scale)**
- Clouds and aerosols: height, thickness, profiles
- Surface pressure
- Chlorophyll fluorescence
- Ocean color

Future

- **589 nm water band available in past datasets (up/down)**
- **5 extended wavelength spectrometers**

HARP – Actinic Flux: Calibration update



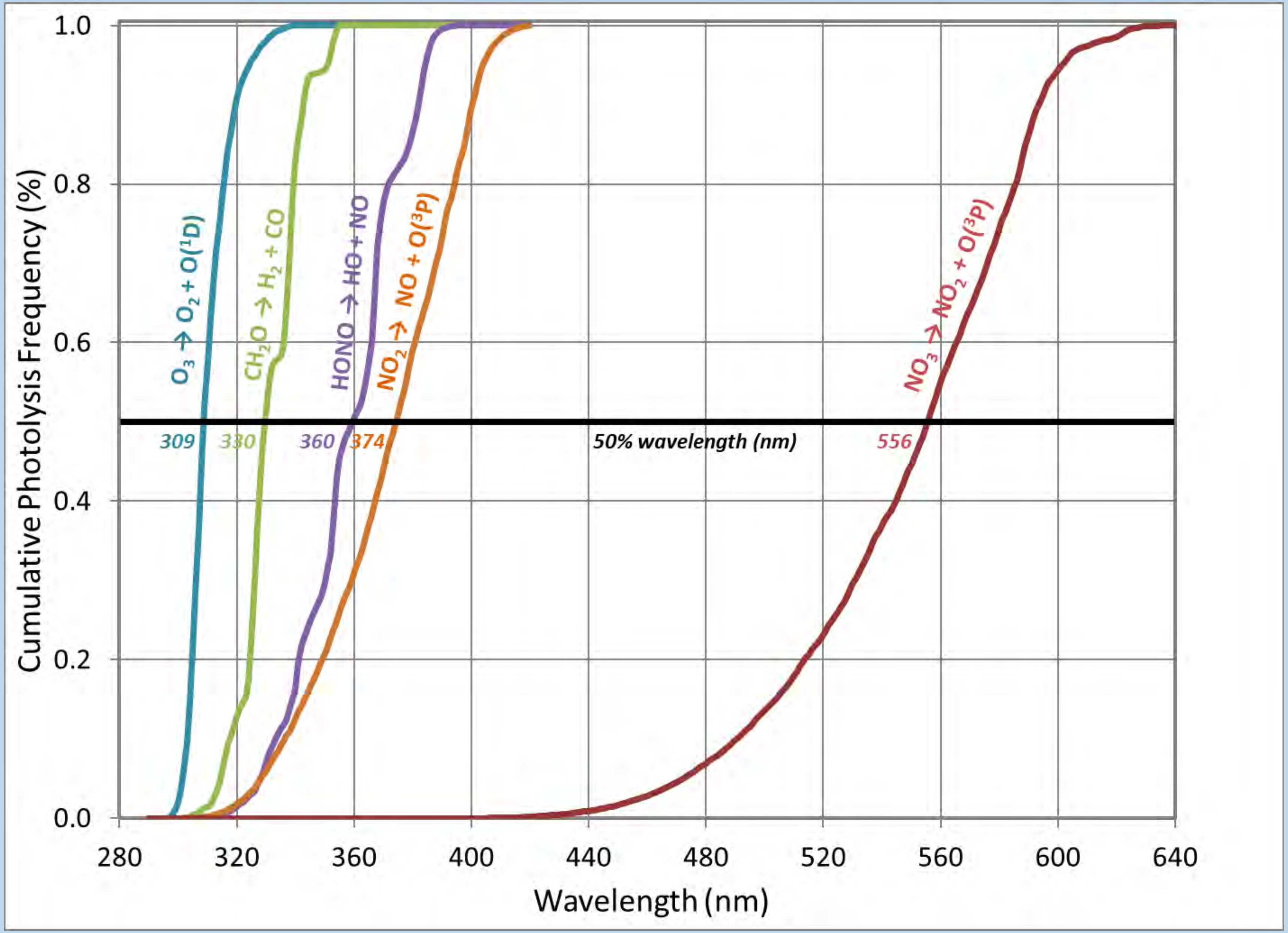
Probability Density Function of jNO_2 meas/model

- All research flights above 10 km
- Variability is primarily from upwelling
- Downwelling optic degraded due to water leak
- Correction greatly improves high altitude relationship to clear-sky model (TUV)

Photolysis frequencies final data

- Mean reductions of 5-15% from field data
- Species corrections vary with spectral dependencies
- Uncertainties increase by ~5% (high sun) due to angular response and calibration

HARP – Actinic Flux: Spectral vs jNO2 measurements



jNO2 derived photolysis frequencies in the UTLS

- Common technique when jNO2 is the only available measured or model-derived photolysis frequency
- How well does jNO2 represent the suite of photolysis frequencies?
- Compare with spectral data

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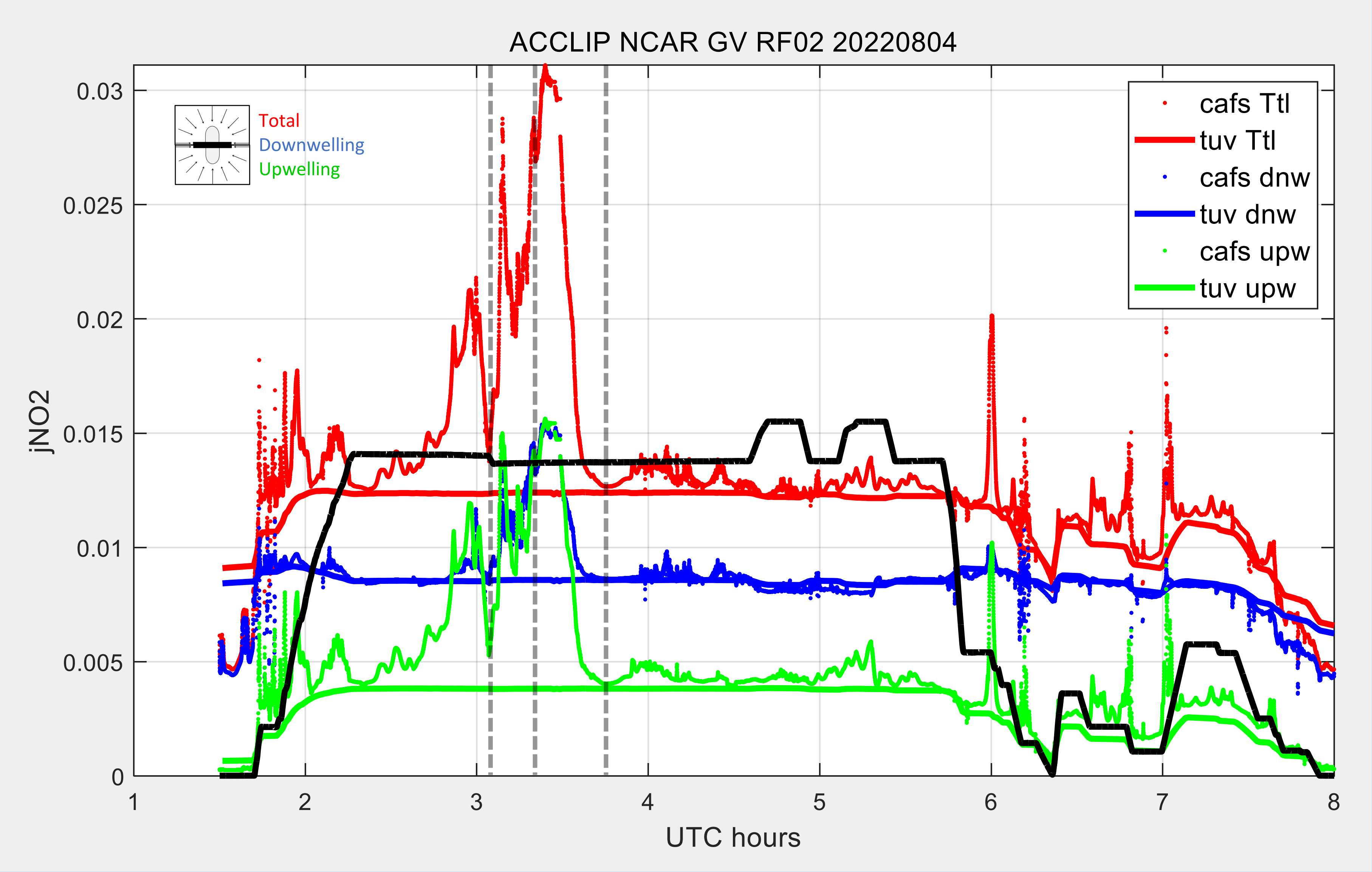

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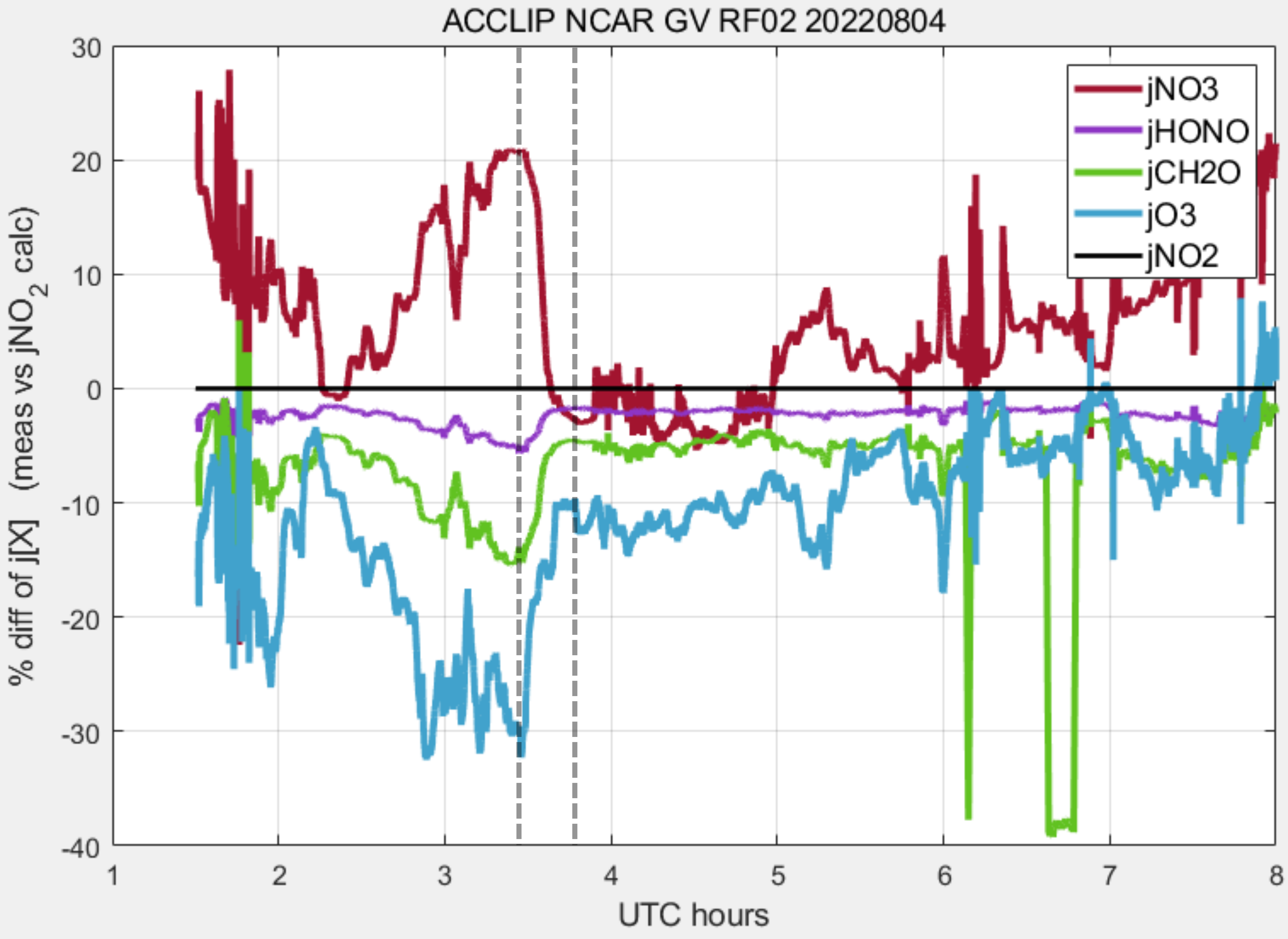

Calculate j-values from jNO2

$$j[X]_{inferred} = j[NO_2]_{HARP} \times \frac{j[X]_{TUV}}{j[NO_2]_{TUV}}$$

Calculate % difference from spectrally derived j-value

$$\%\ diff = \frac{(j[X]_{HARP} - j[X]_{inferred})}{j[X]_{HARP}}$$

Calculate change in % diff from cloud to clear

J-value	In cloud – clear:
jNO3	-24%
jHONO	+4%
jCH2O	+10%
jO3	+22%

Summary

- NIR actinic flux calibrations require additional work for absolute accuracy
- Water vapor and oxygen A-band absorption is clearly present in the data. How can we use this effectively?
- ACCLIP photolysis frequencies have been significantly corrected from the field data
- Calculating a suite of photolysis frequencies from jNO2 requires some care. Many models have limited capability to do so.