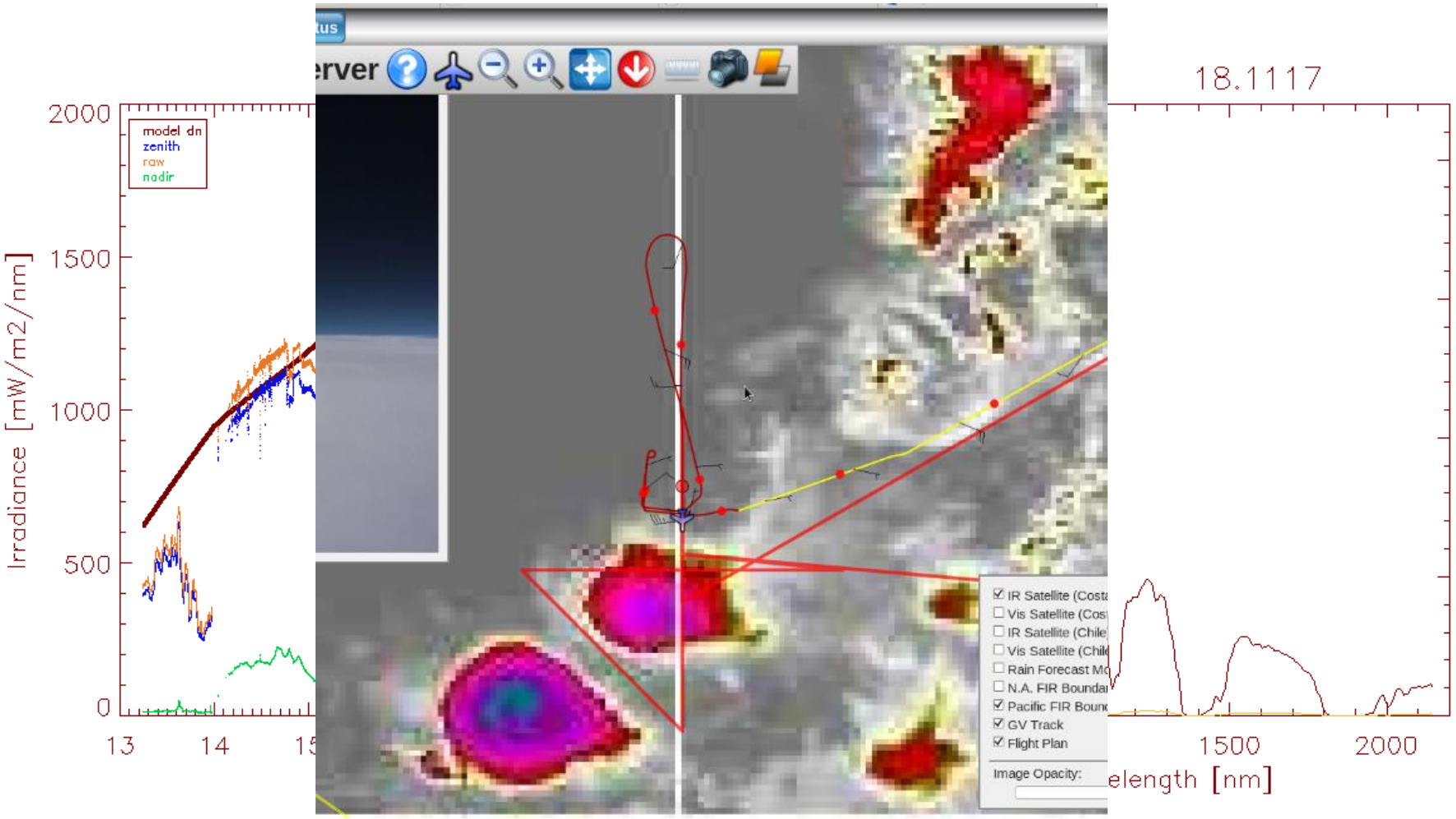
Deriving Cloud and Ocean Color Products from Spectral Irradiance Measurements with HARP

Sebastian Schmidt, Shi Song, Samuel Hall, Samuel LeBlanc

Overview

- Rocky start (problems with leveling platform caused problems)
- Sorted out calibration by cross calibration during DC3 (GV vs. DC-8)
- Now improving azimuthal response of light collectors (NCAR/CU)
- Data inspired new approaches for cloud retrievals (Samuel LeBlanc)
- Now have spectral cloud retrieval that is less sensitive to spectrally neutral biases – already used for thermodynamic phase retrieval
- Ocean color – only case 1 waters encountered
- Data set useful for 3D cloud radiative forcing work (Shi Song)

Sample HARP Data



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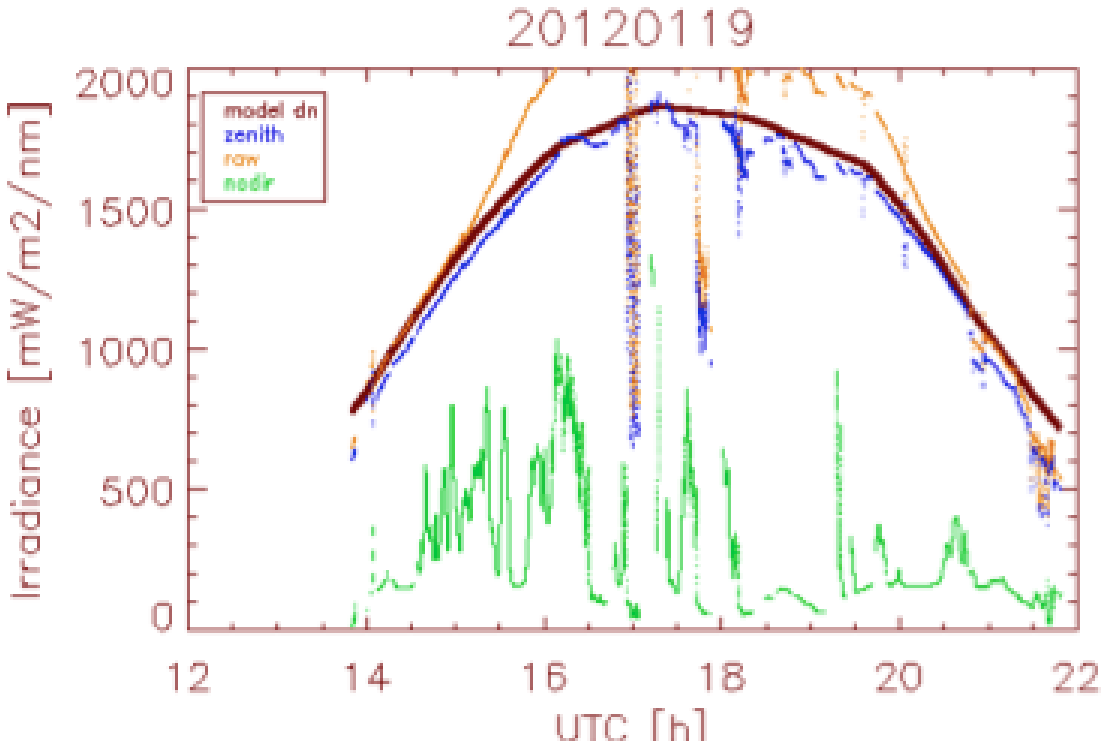


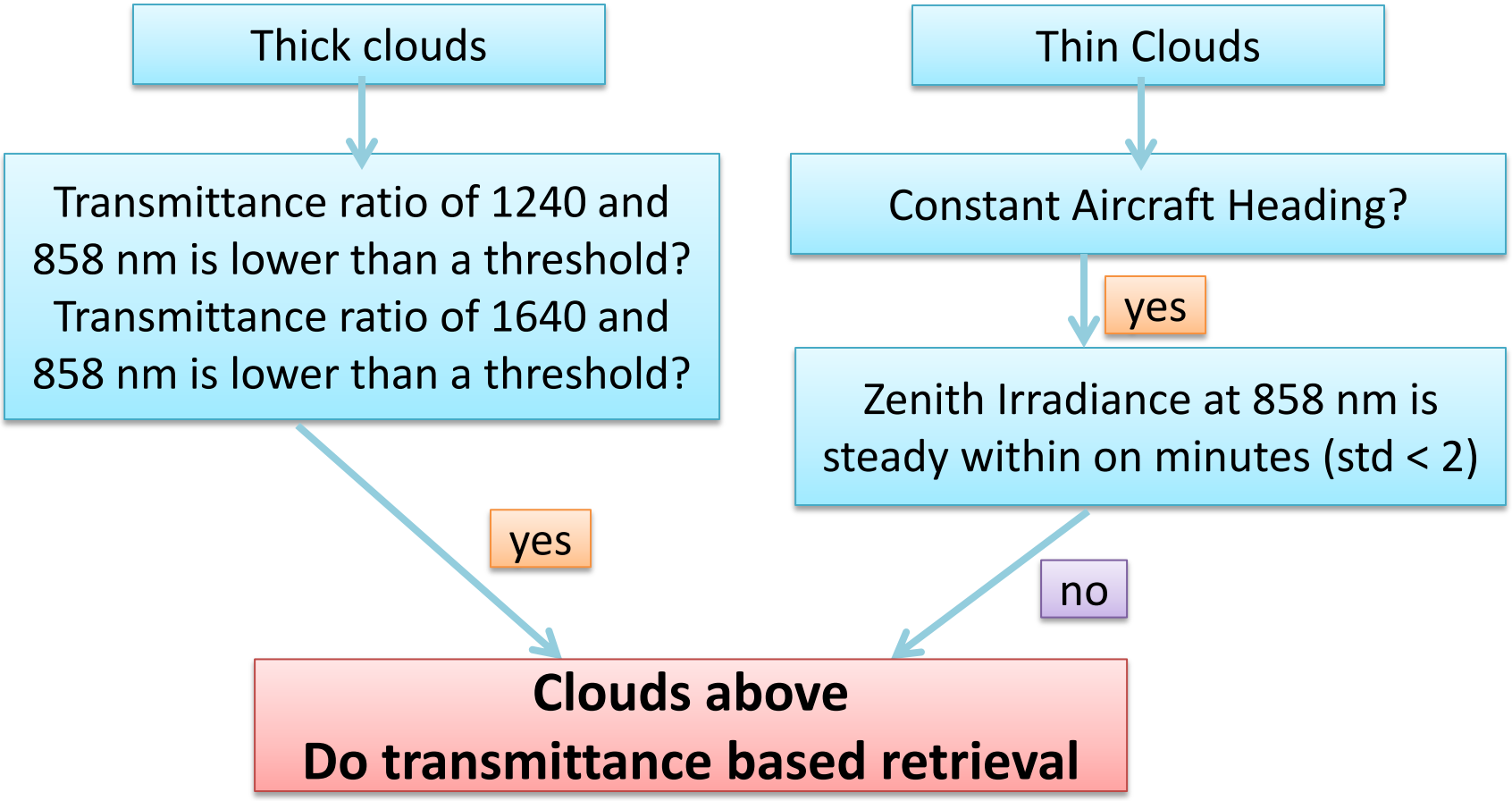
What did we do to correct data?

- Cal (cross-cal)
- Dedicated circles (reflecting cloud effect; azimuthal resp)
- Use spectral rather than absolute techniques for cloud detection (somewhat less sensitive but more reliable)
- Best use of data may still be coming (direct GOES-derived fluxes with measurements)

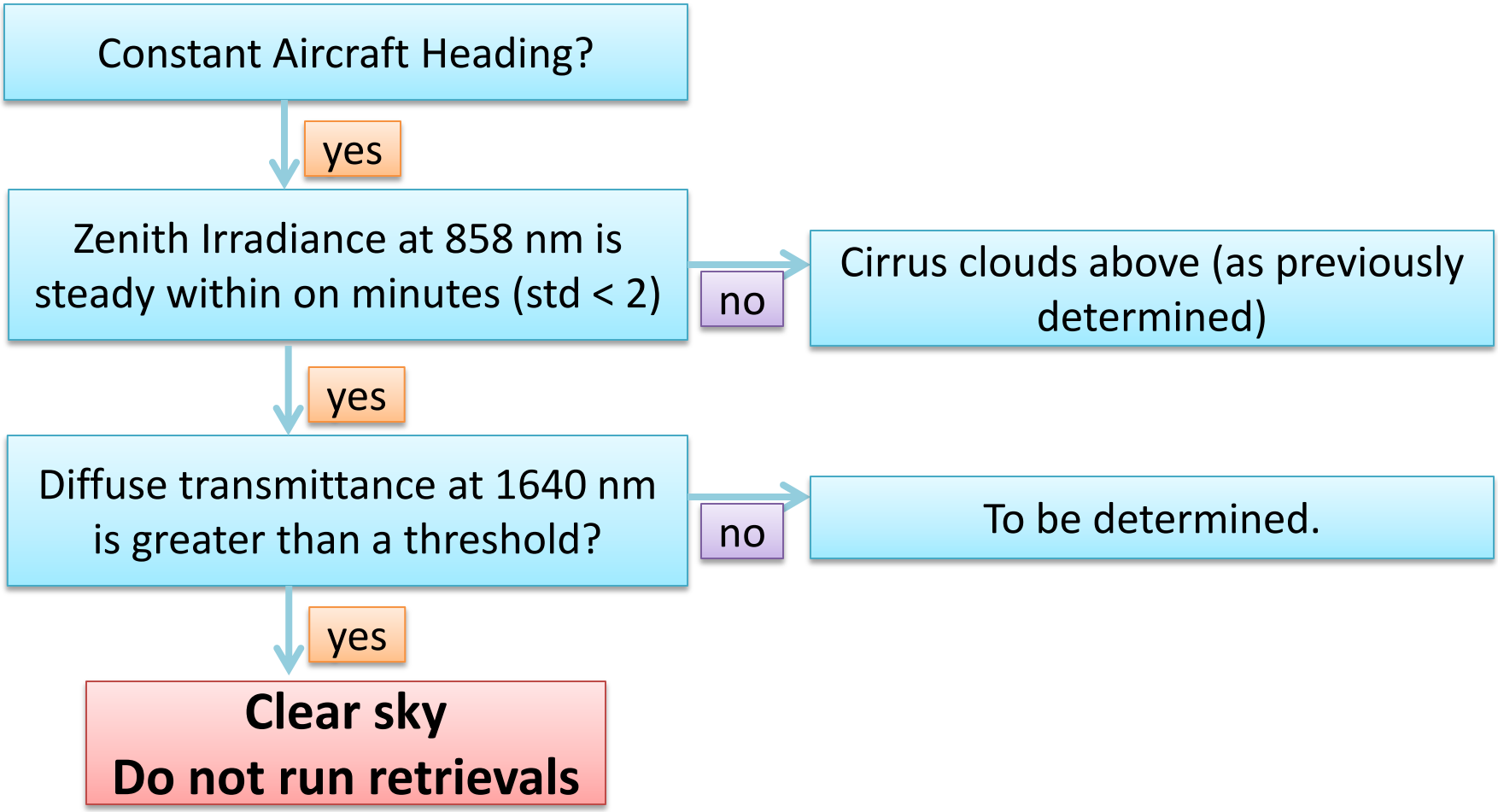
Cloud Retrievals Overview

- *Effective Hemispherical* cloud properties (HARP measures irradiance, not radiance!)
- Thermodynamic Phase, Cloud Optical Thickness, Effective Radius
- Transmittance / Reflectance mode available
- Currently COD>4 threshold for semi-operational product
- Lower threshold for research product
- Currently archive at 1 min intervals, will upload high-res version if useful

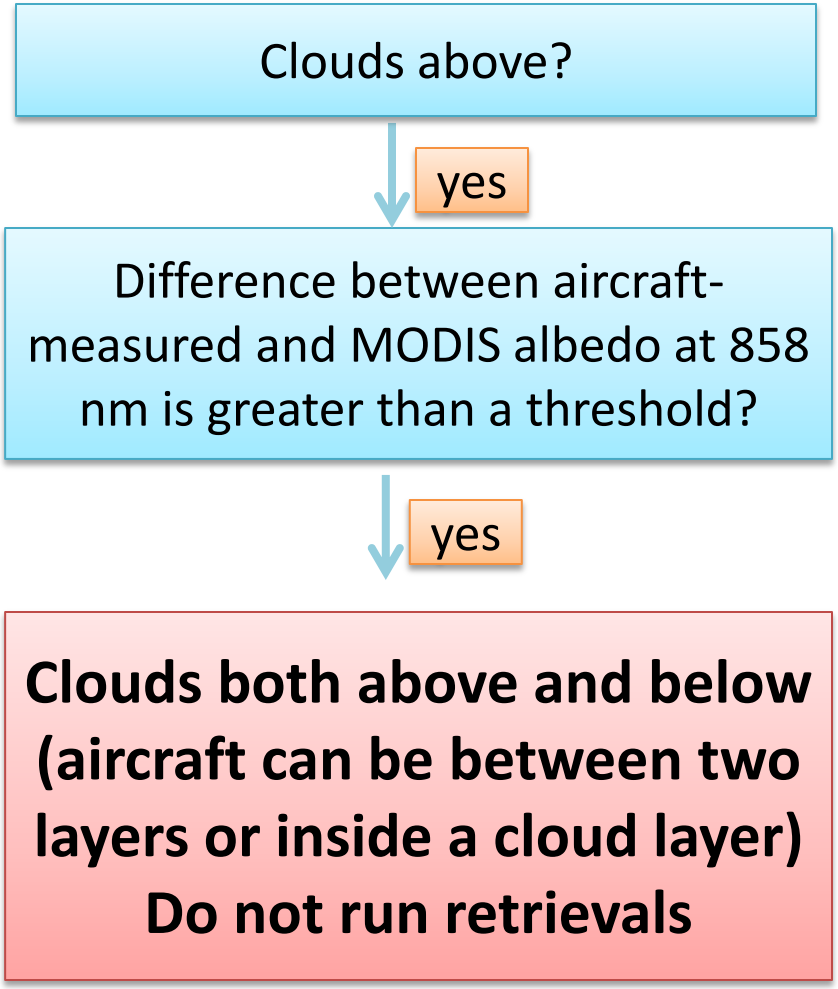
Cloud mask – clouds above



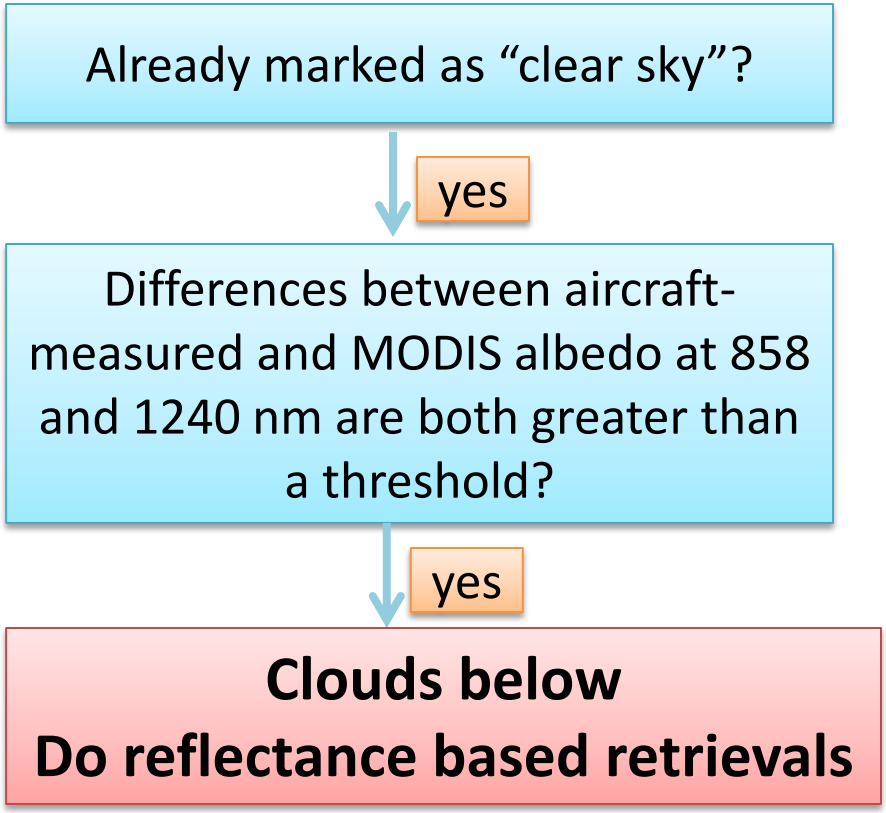
Cloud Mask – clear sky



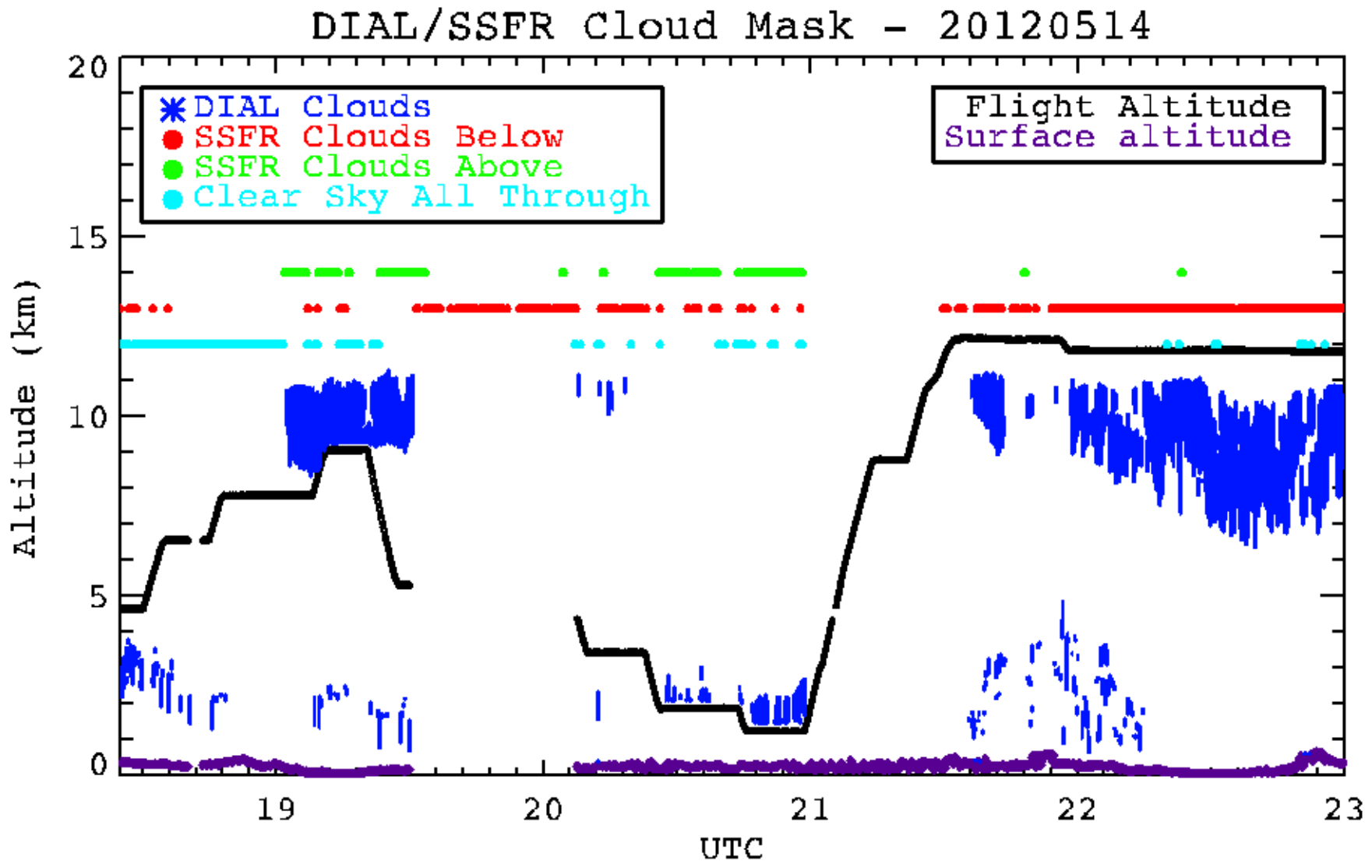
Cloud Mask – clouds above and below



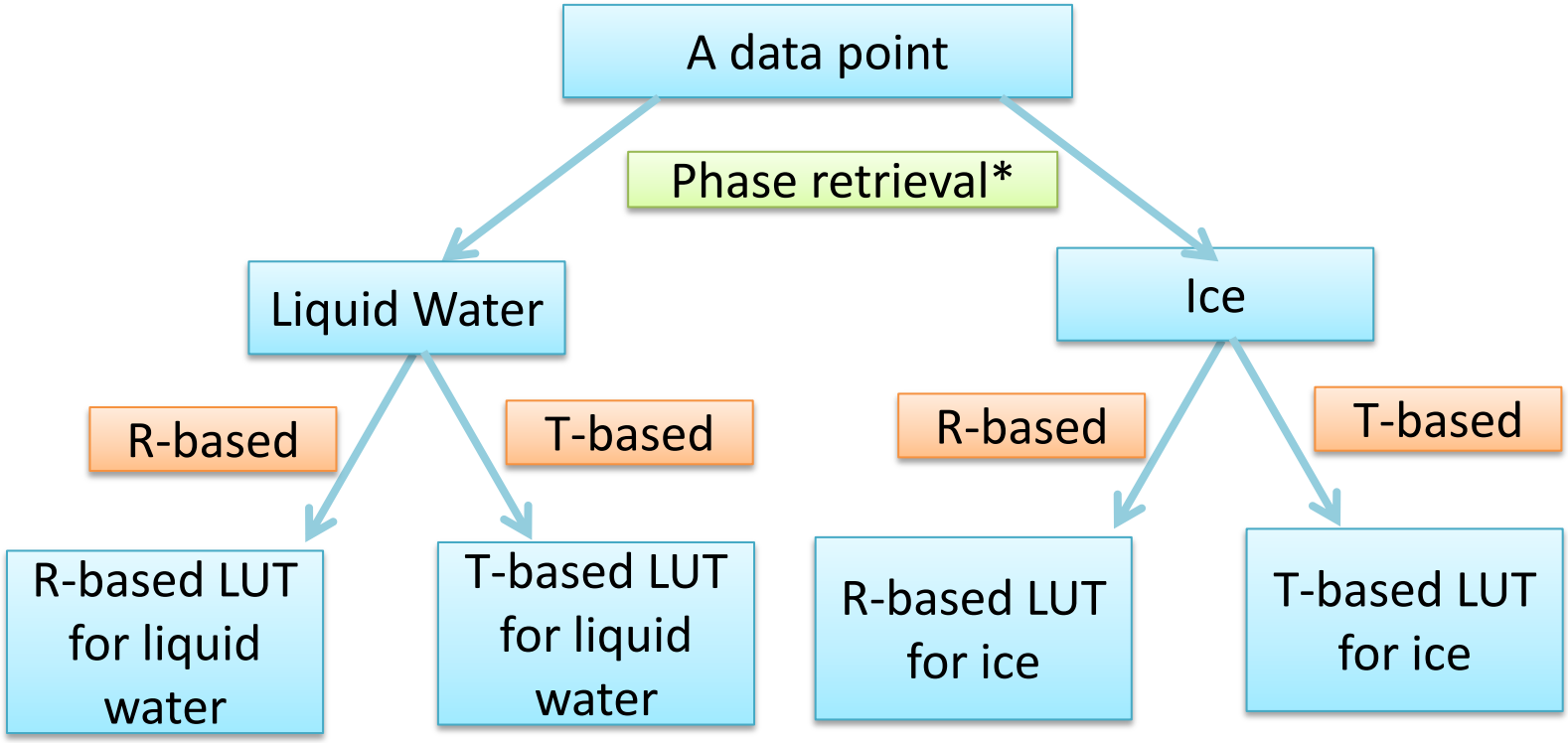
Cloud Mask – clouds below



Automated Cloud Mask



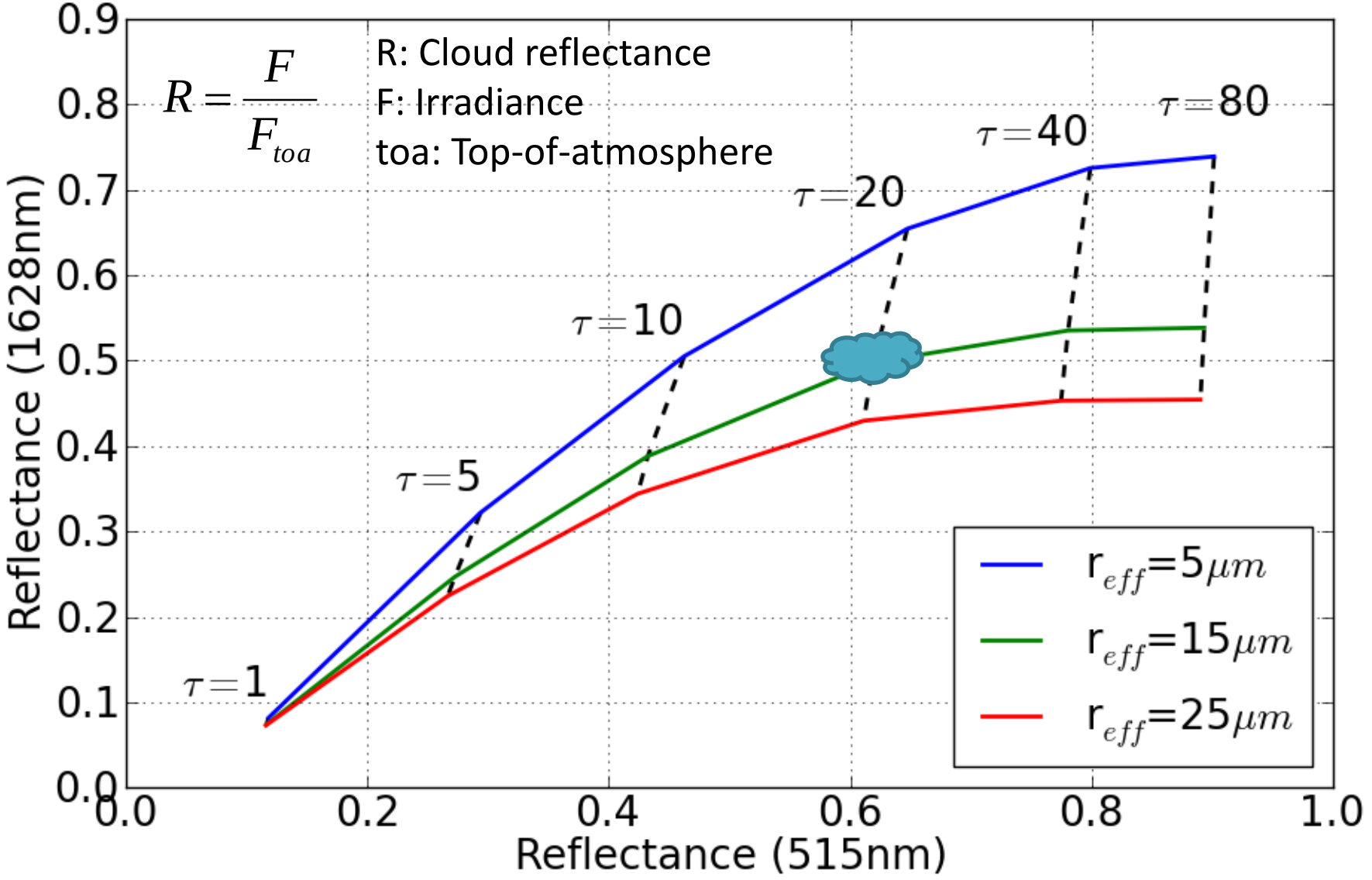
Float chart of retrievals



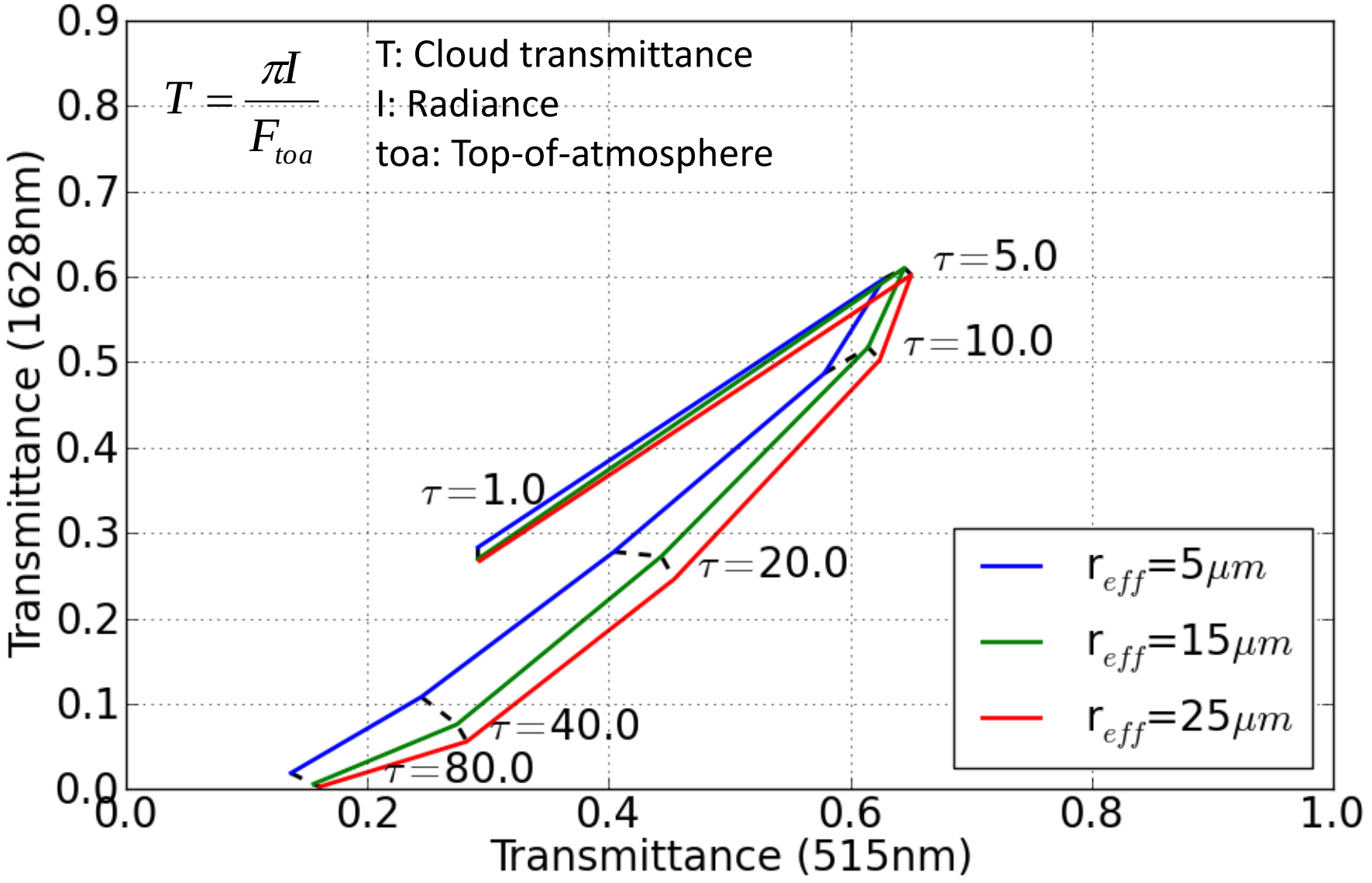
- phase discrimination method: Knap et al., 2002, AMS + LeBlanc et al., 2014
- LUT starts from optical thickness of 0.5, but retrievals with optical thickness less than 4 are flagged as not valid and discarded

Cloud Reflectance Retrievals

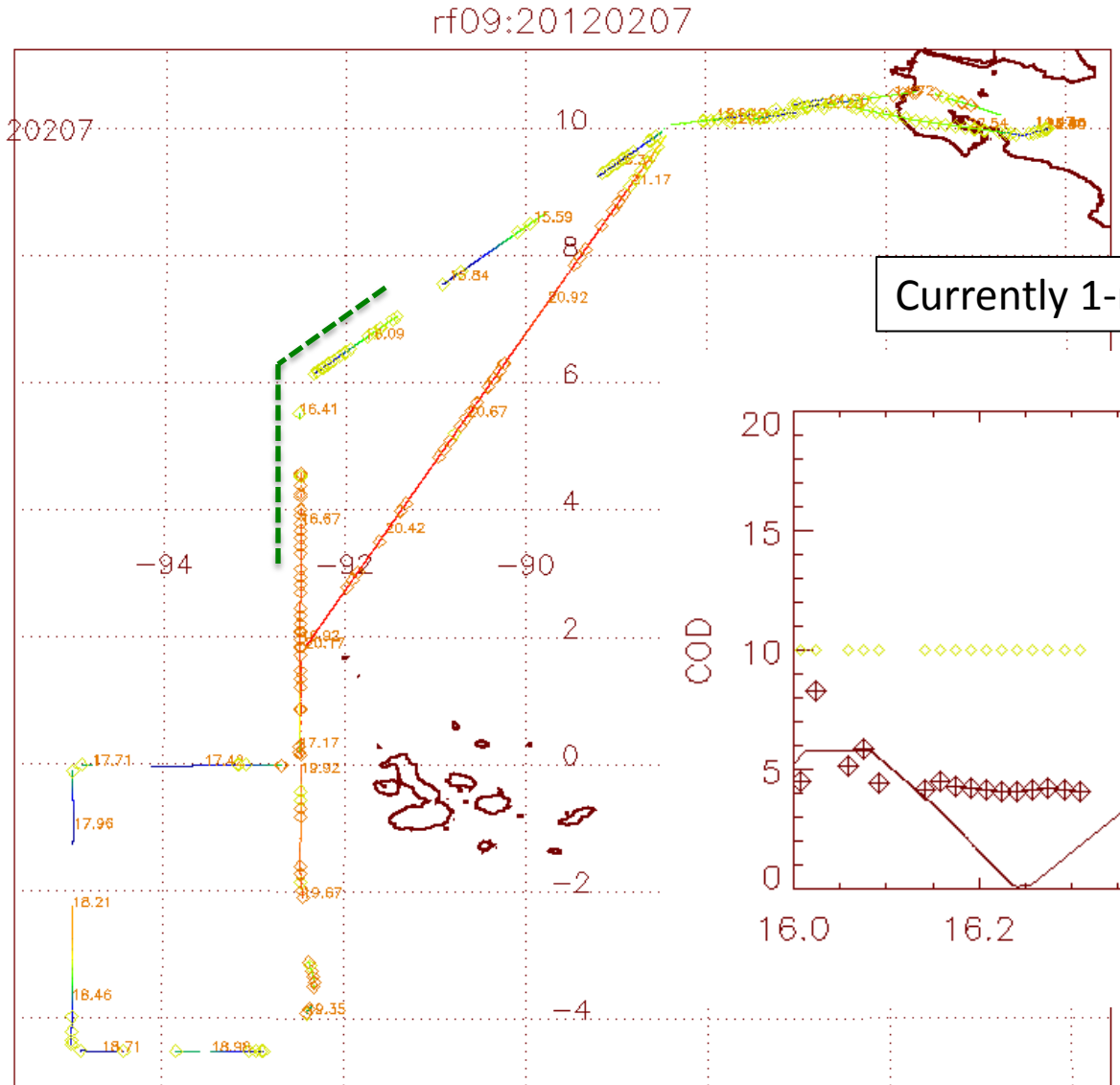
Used *modeled* instead of *measured* downwelling irradiance



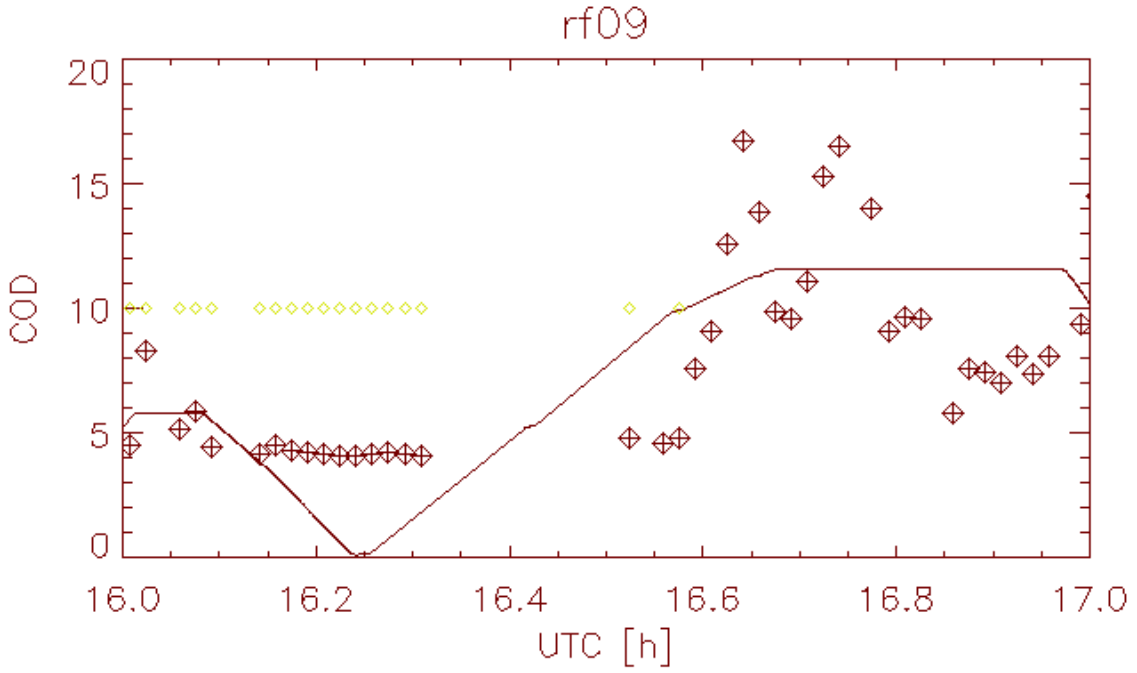
Cloud Transmittance Retrievals



Consistency between transmittance and reflectance-based retrievals



Currently 1-minute data in archive



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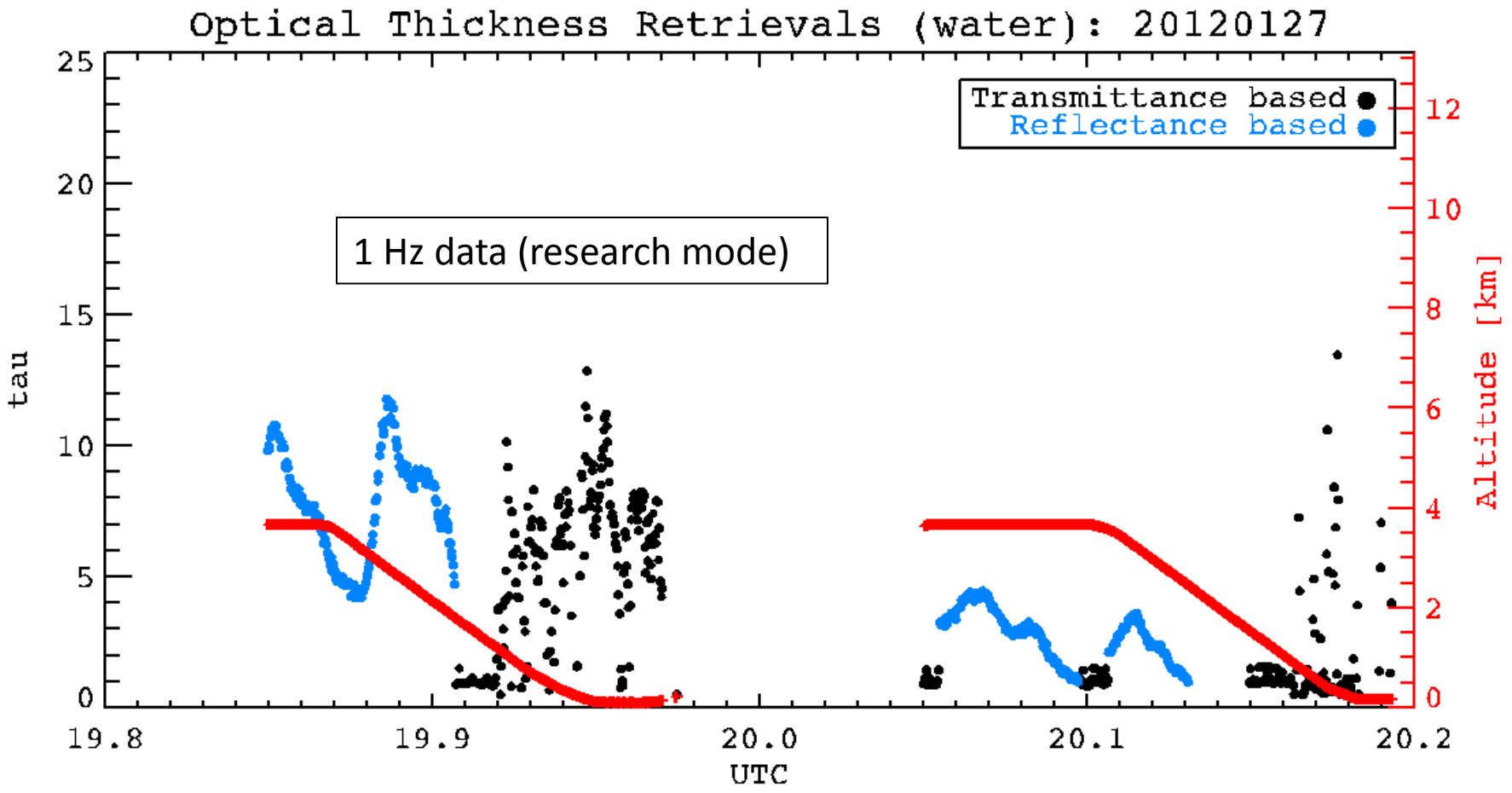
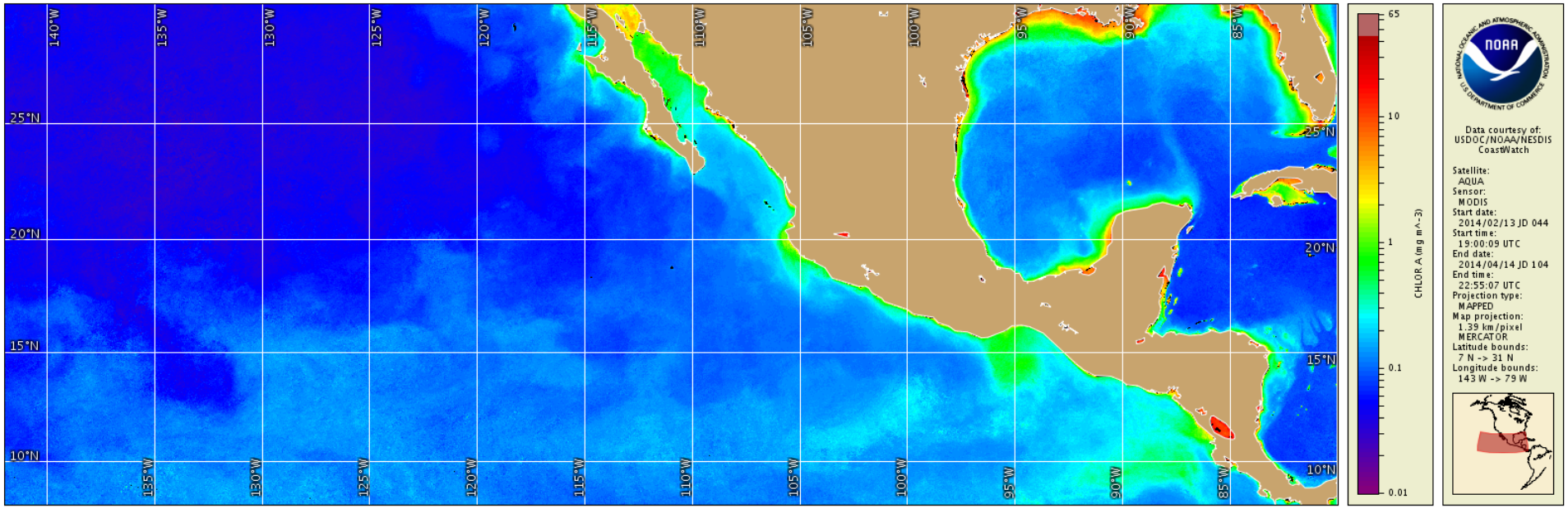


Ocean Color from HARP

Chlorophyll hotspots are in coastal zones.
This is often in “case B” waters (with dissolved organic/inorganic matter)
Original plan was to separate these features using the high HARP spectral resolution



http://www.ospo.noaa.gov/Products/ocean/color.html

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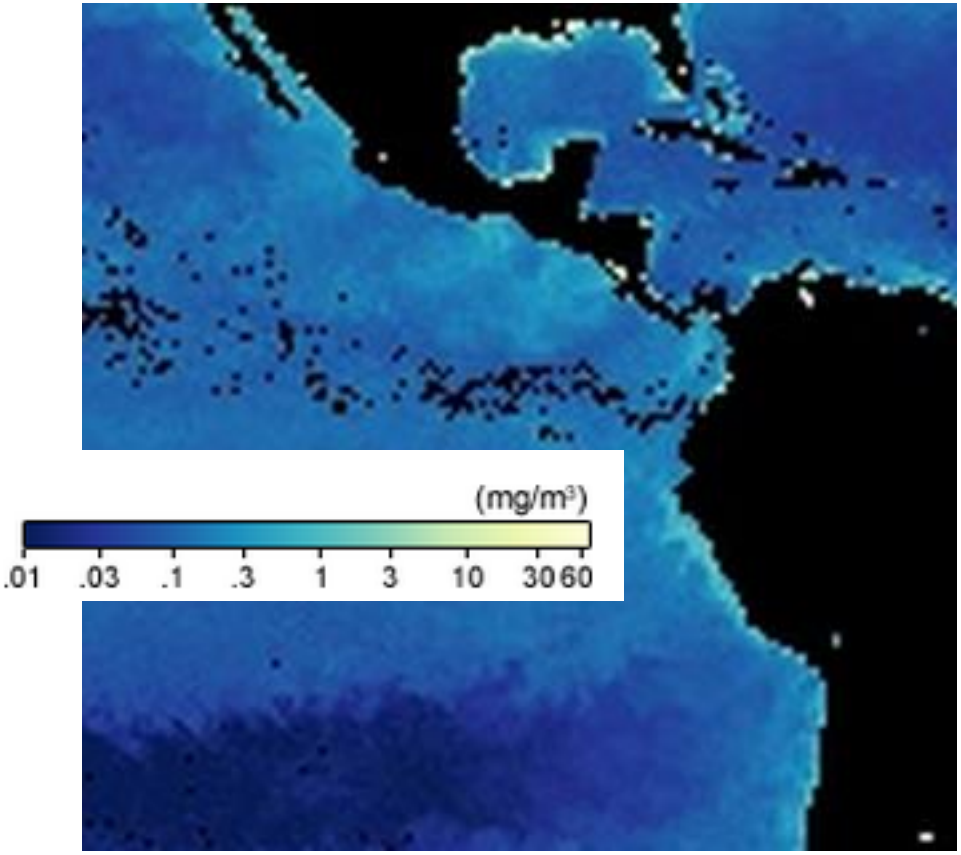

January 2012 situation
…this is also available in KMZ and can be overlaid with our data (TBD)

Could be useful for, e.g., ACE project, in defining satellite channels etc.

Advantage of HARP: Higher spectral resolution than even AVIRIS or any OC imager in space

http://neo.sci.gsfc.nasa.gov/view.php?datasetId=MY1DMM_CHLORA

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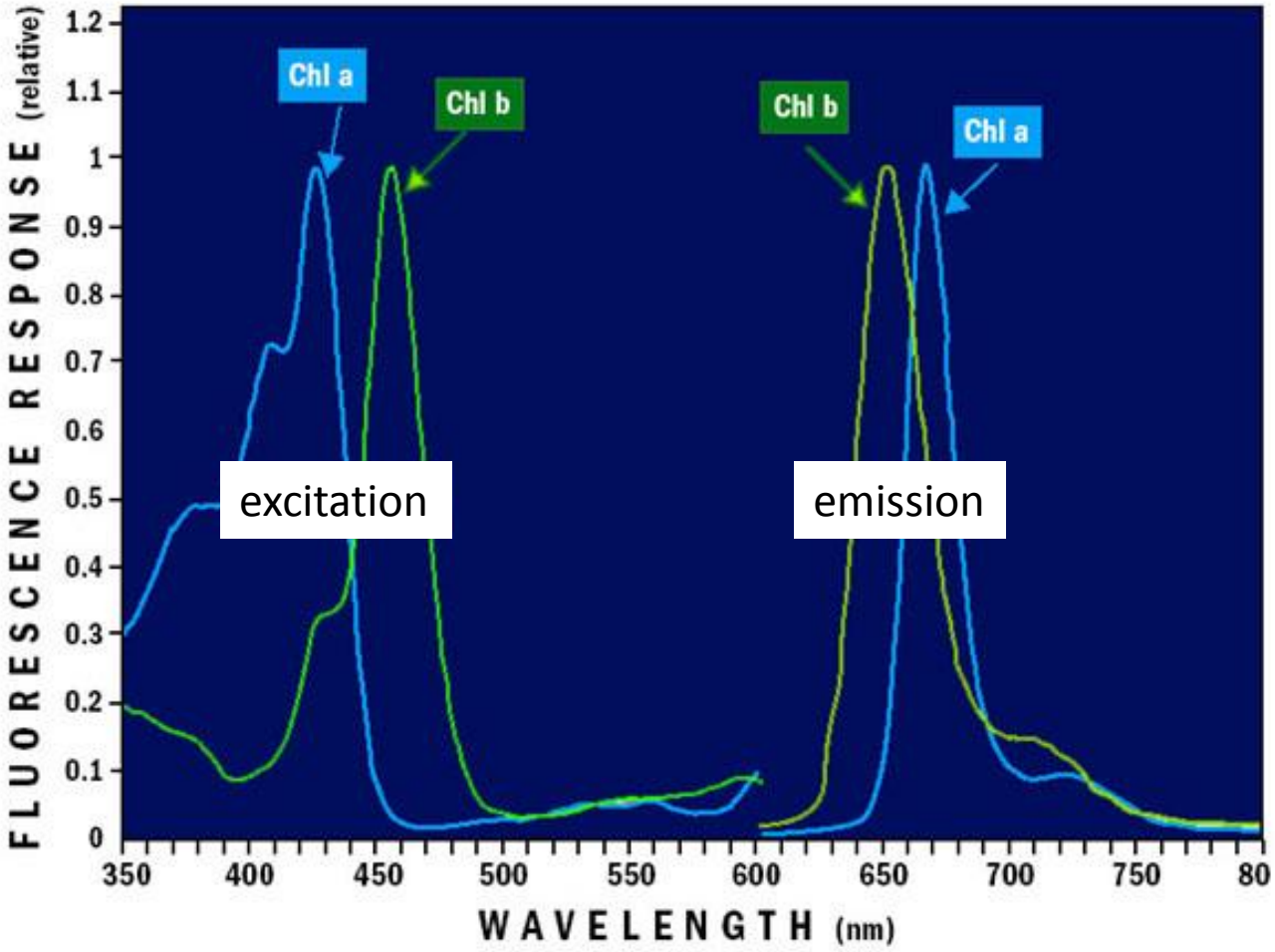

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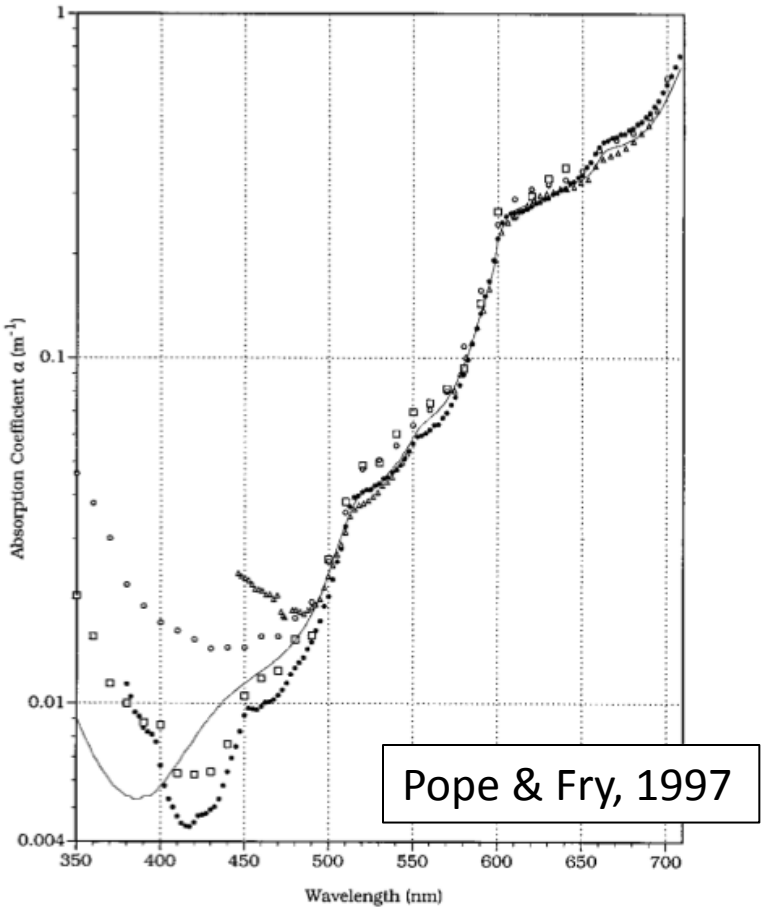


Fig. 10. Present results (●) for the absorption of pure water plotted with those from Buiteveld *et al.*[2] (smooth curve), Tam and Patel[4] (△), Smith and Baker[6] (○), and Sogandares and Fry[3] (□).

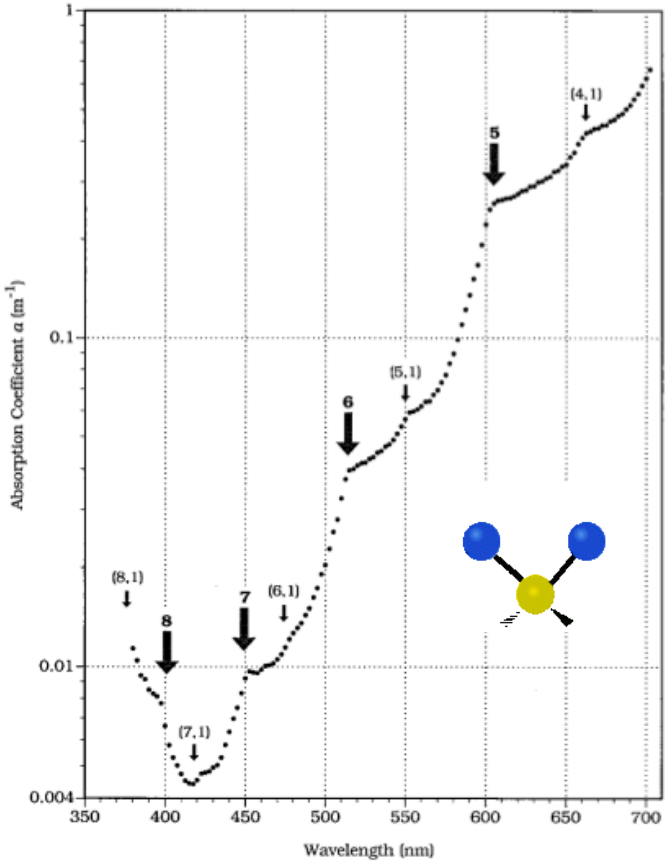
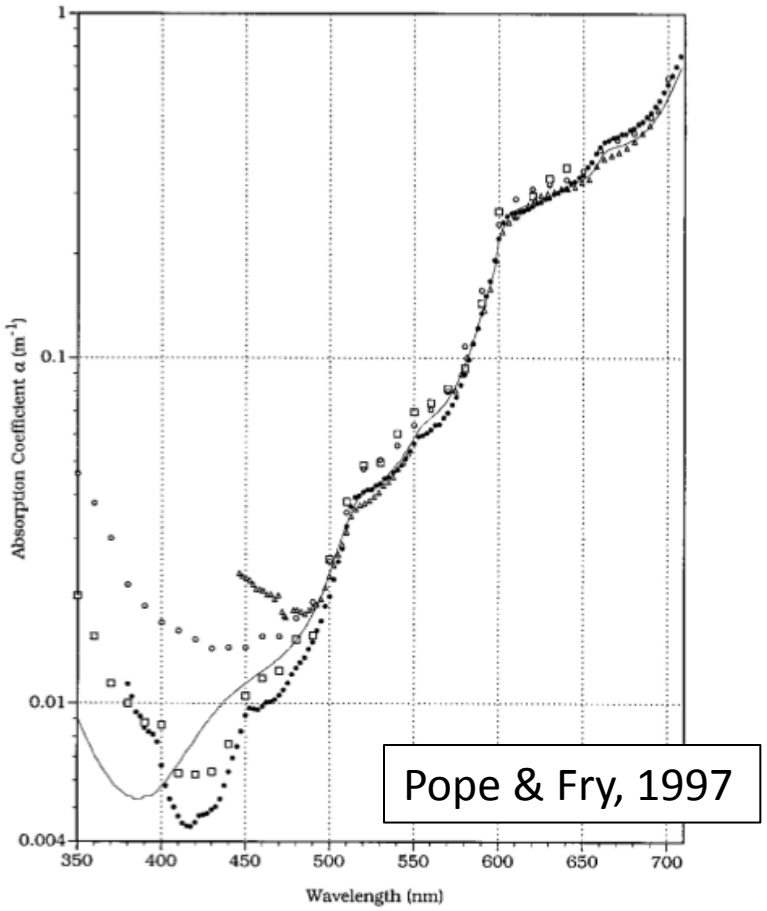


Fig. 12. Present results for the absorption of pure water. A large arrow with a boldface integer **n** indicates the predicted position of a shoulder that is due to the *n*th harmonic of the O–H stretch; the small arrows with mode assignments (*j*, 1) indicate the predicted position of a combination of the *j*th harmonic of the O–H stretch with the fundamental of the scissors mode.

Ocean Color from HARP



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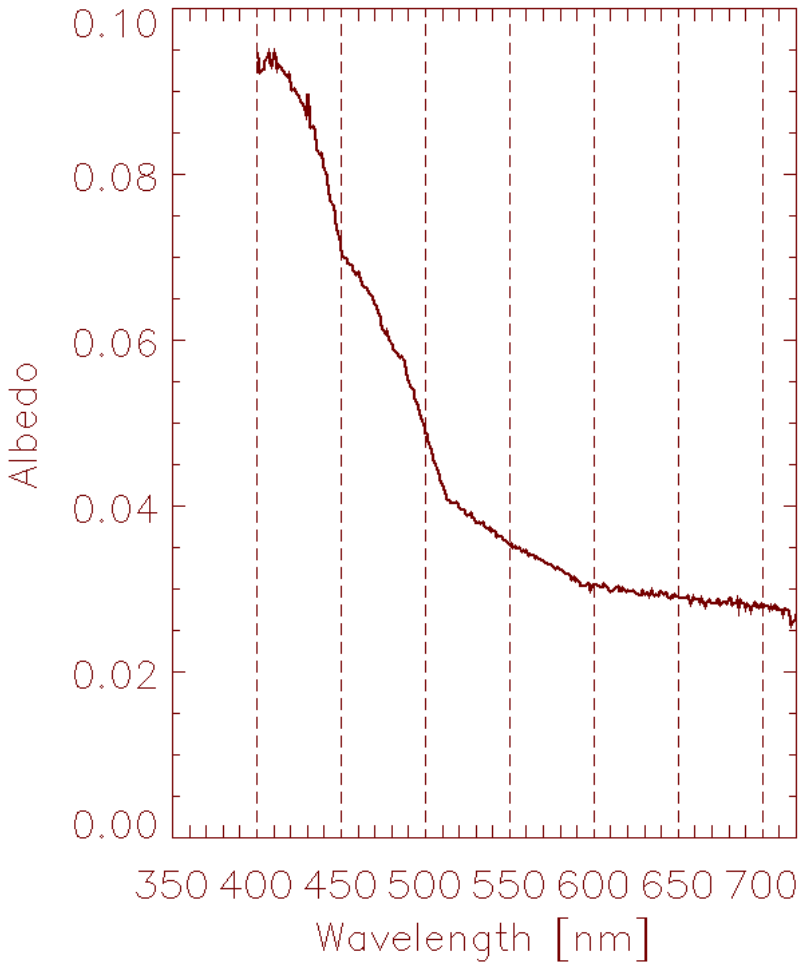
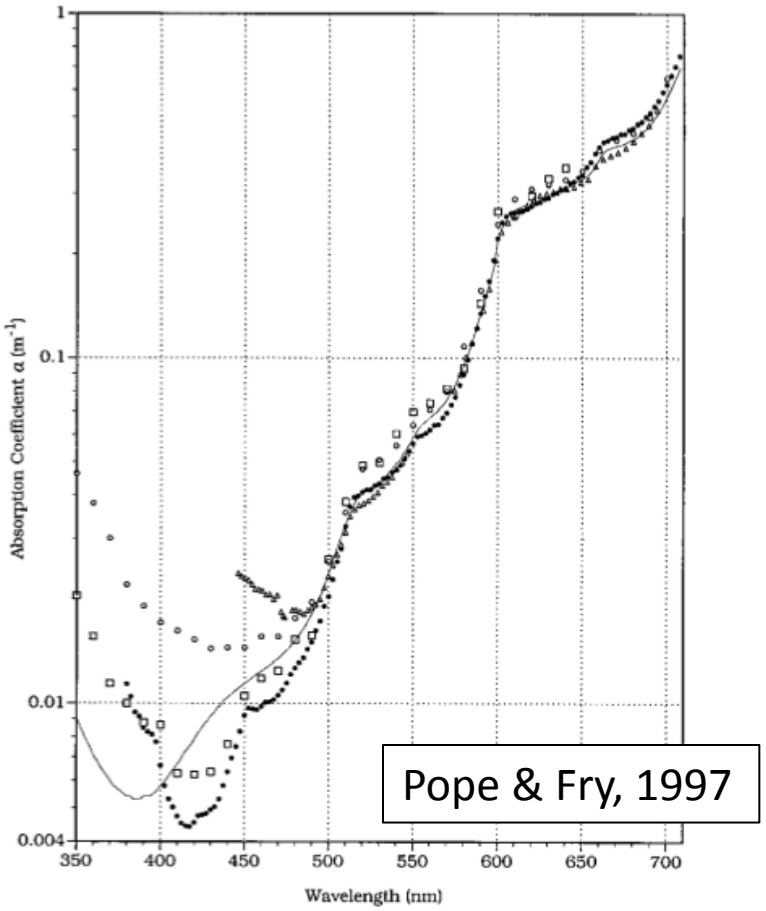


1/24/12, UTC=15.7 h

Ocean Color from HARP



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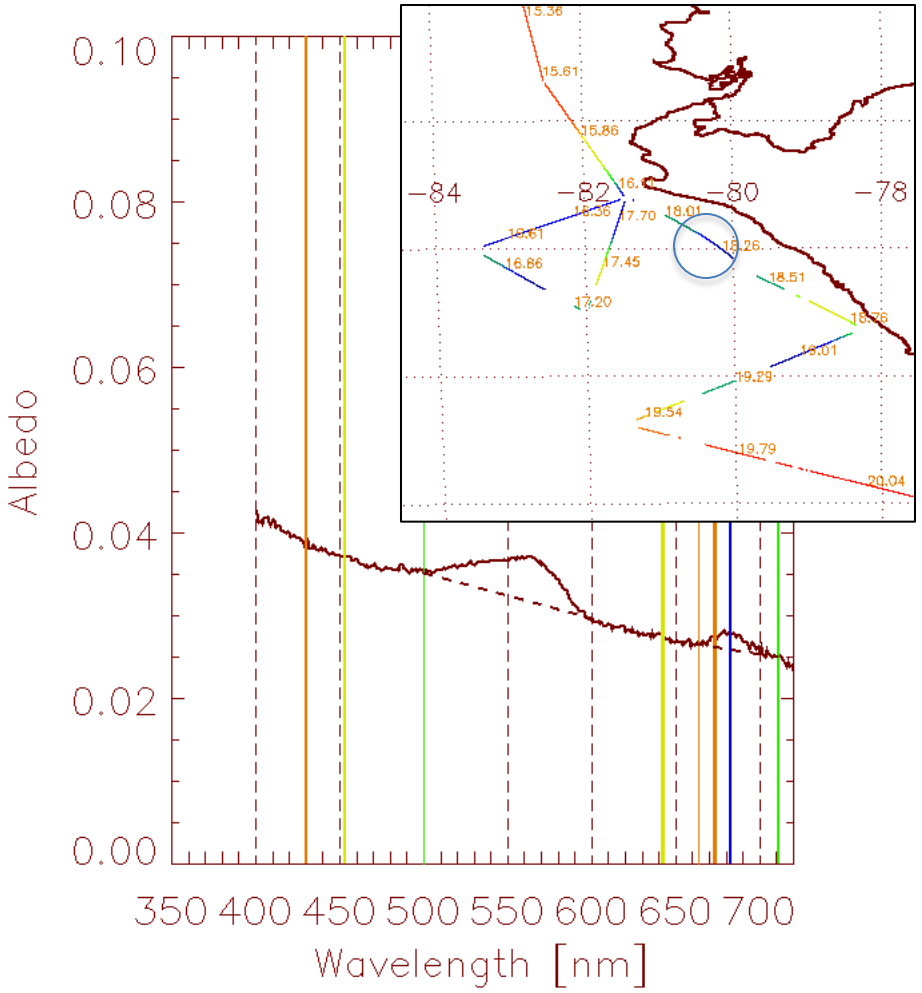
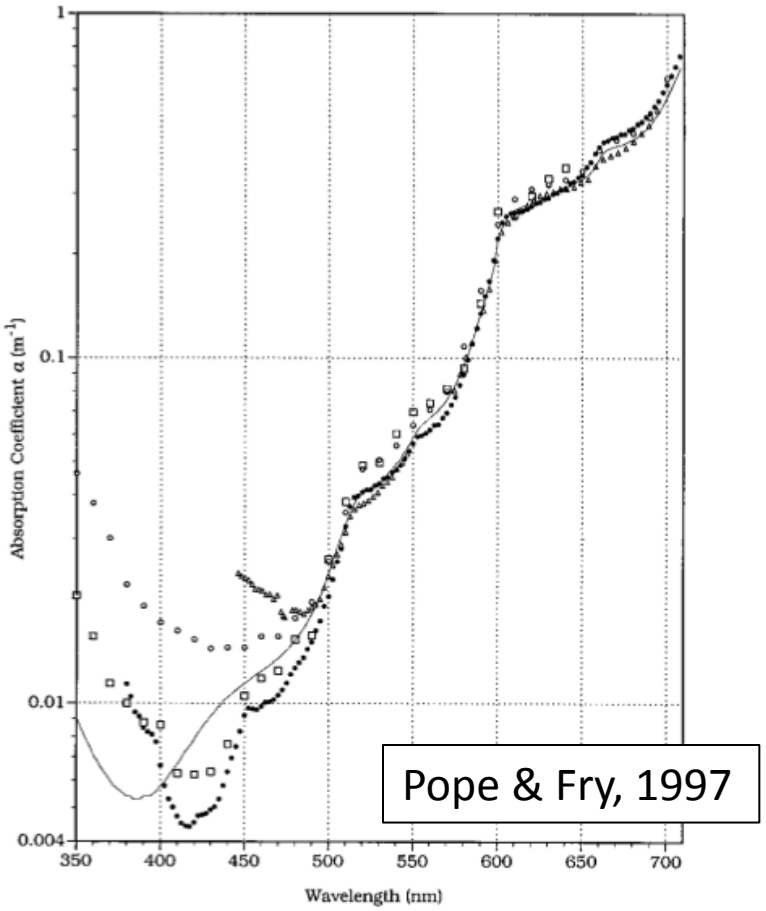


1/19/12, UTC=18.3 h

Ocean Color from HARP



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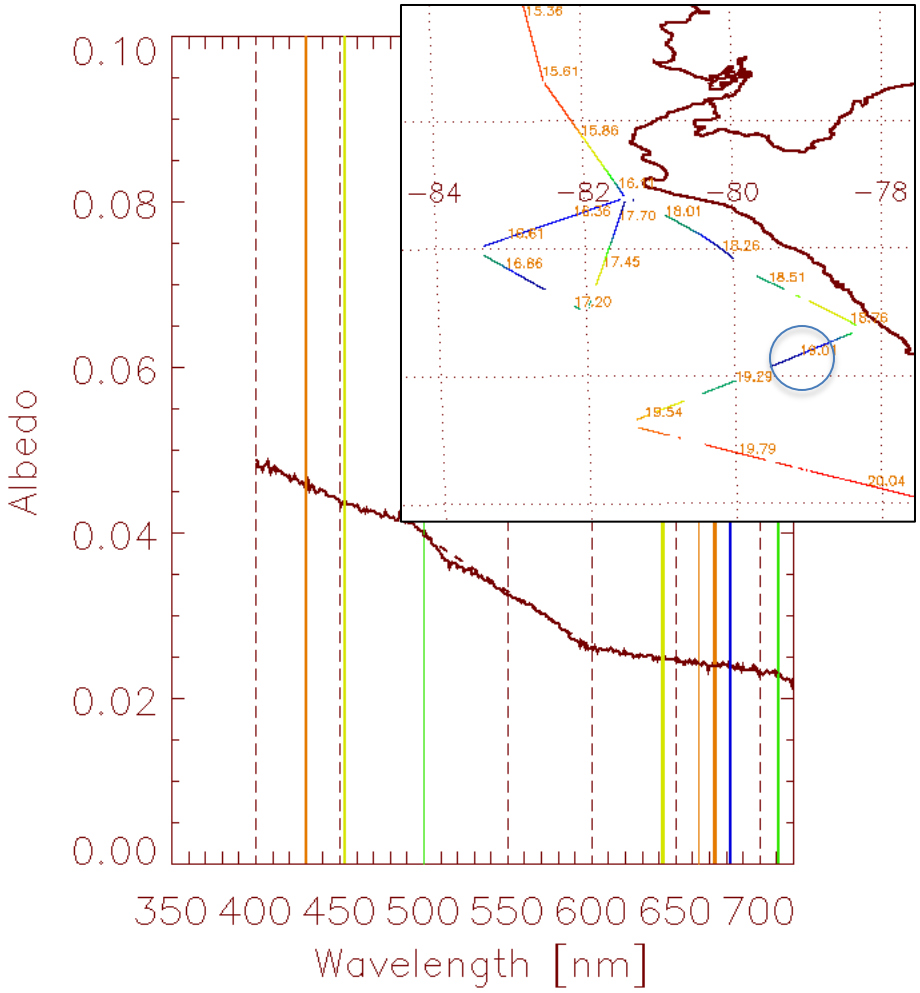
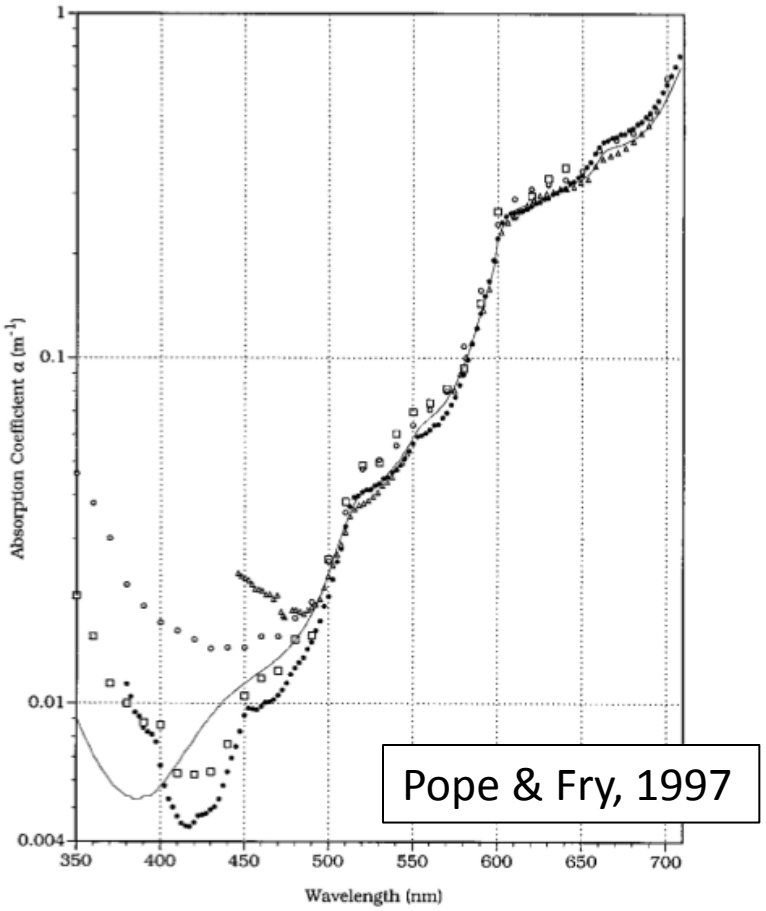


1/19/12, UTC=19.1 h

Ocean Color from HARP



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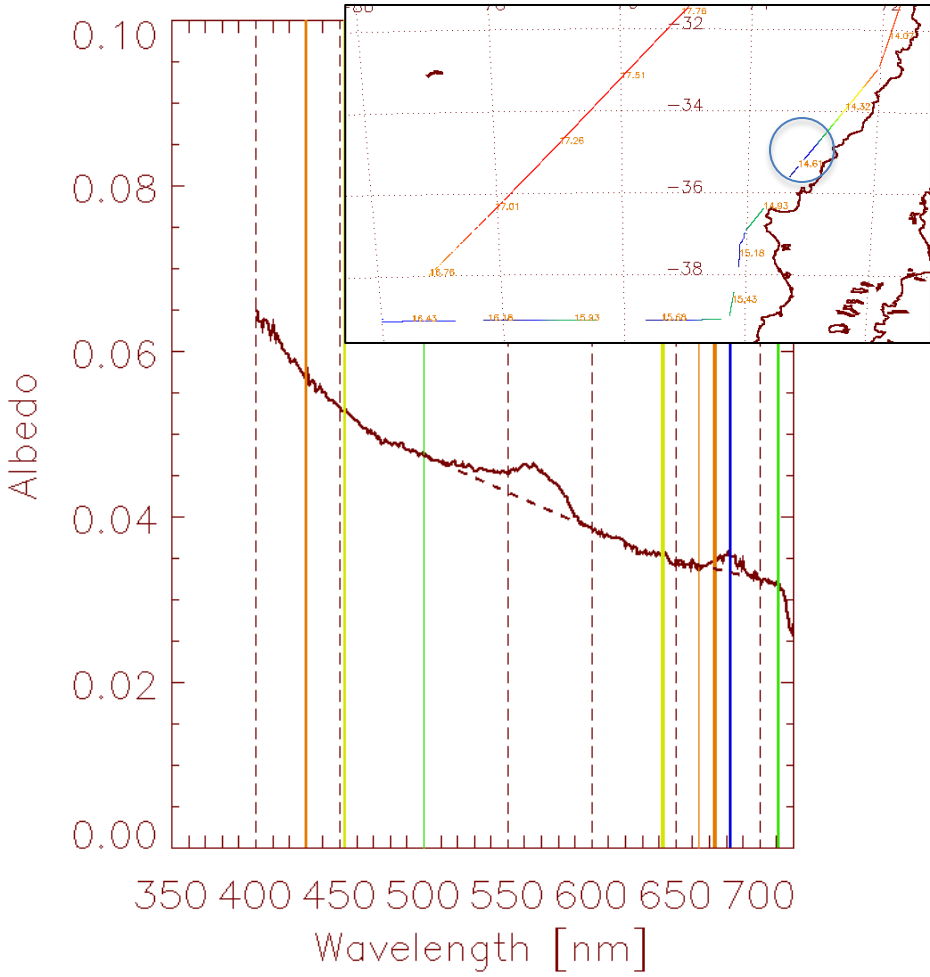
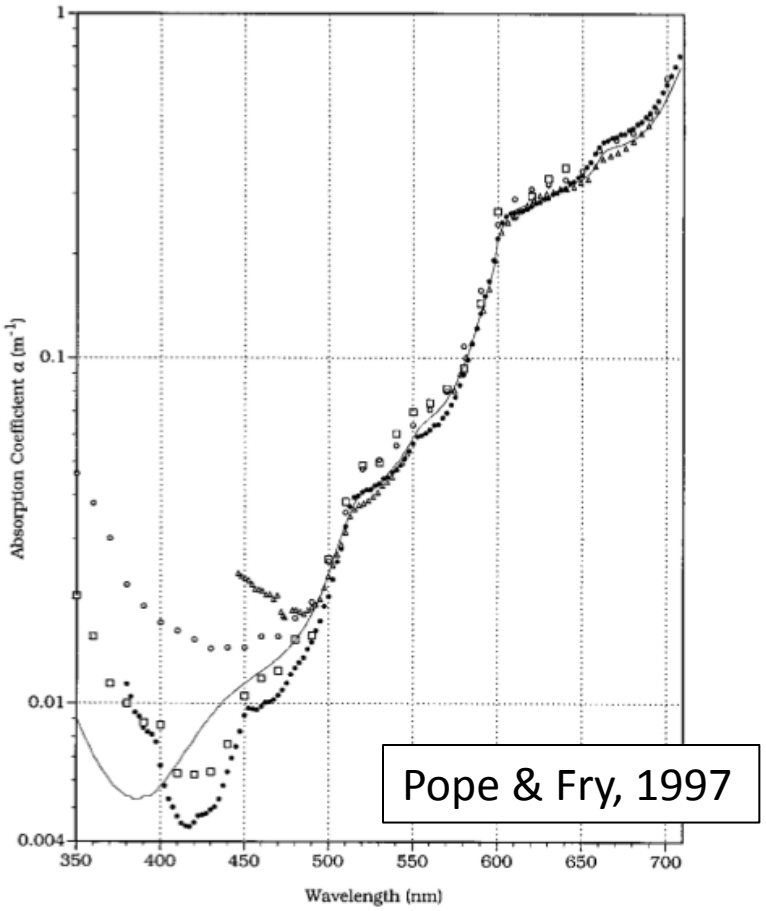


1/27/12, UTC=14.7 h

Ocean Color from HARP



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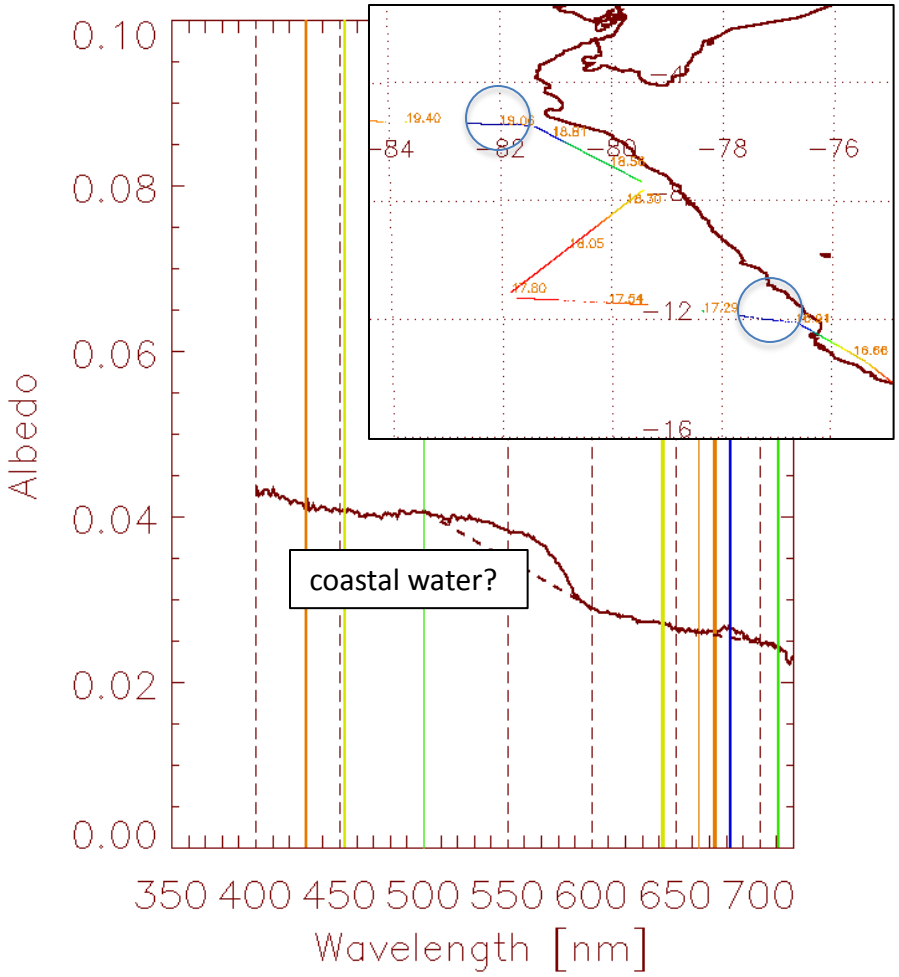
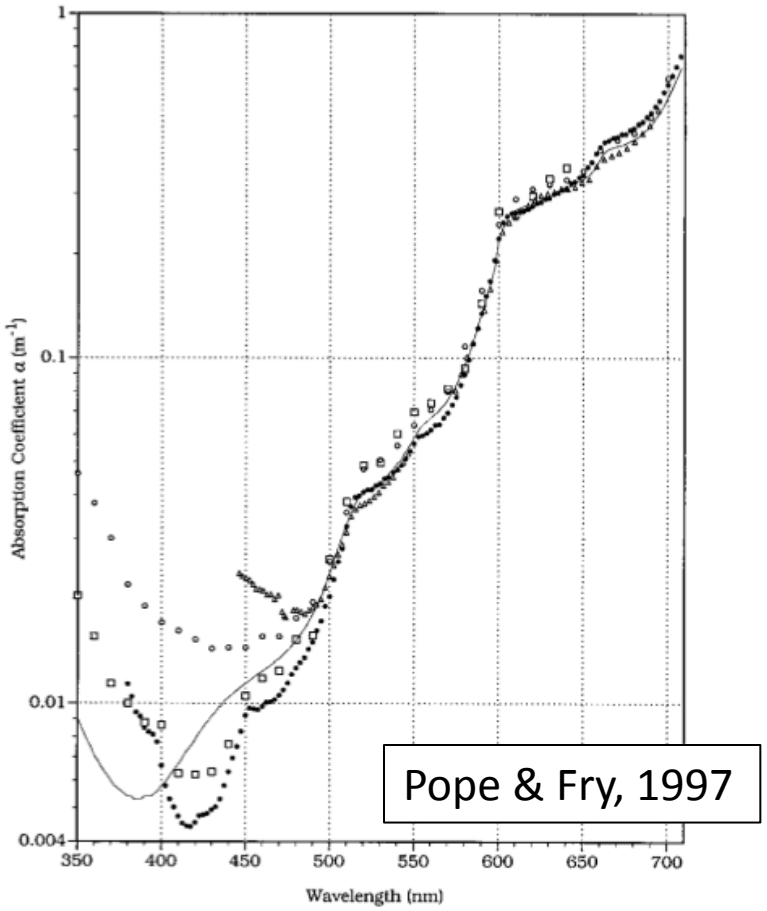


1/31/12, UTC=17.1 h

Ocean Color from HARP



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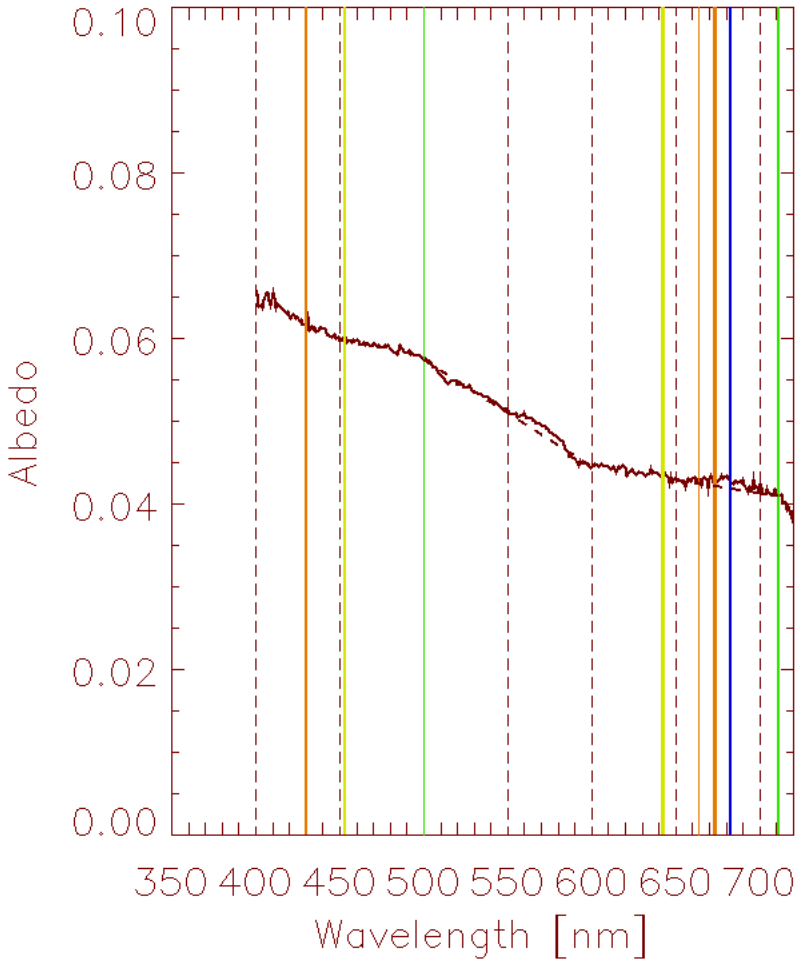
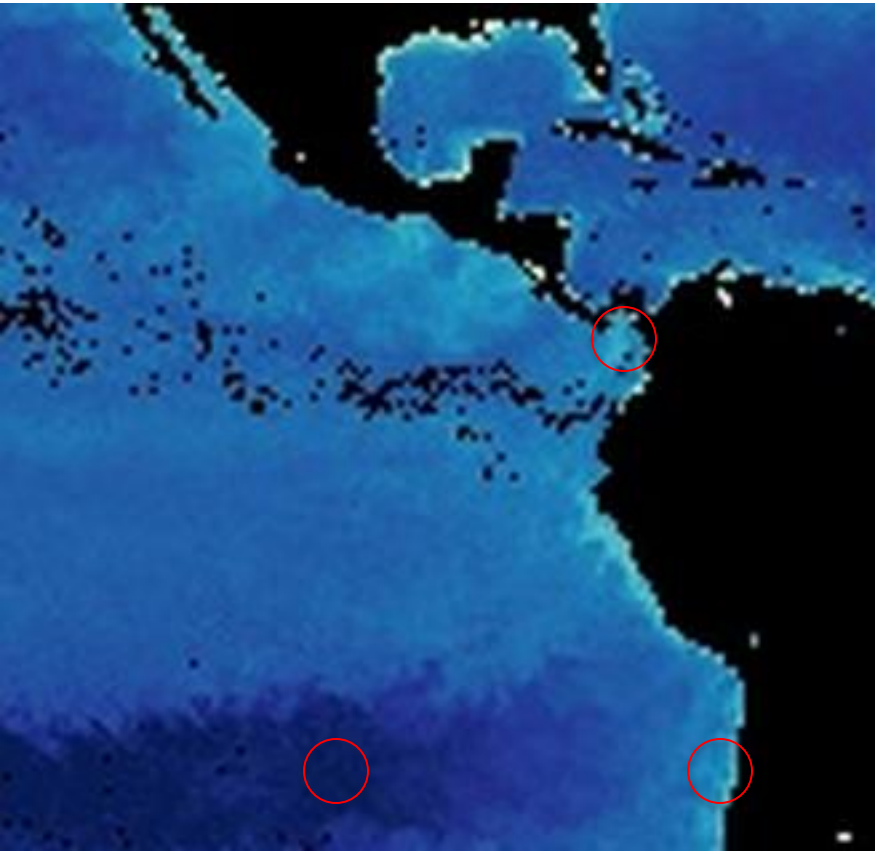


1/31/12, UTC=19.1 h

Ocean Color from HARP

Summary / Plans



- No case-2 waters (pristine)
- Elevated chlorophyll only in coastal areas, weaker off the coast
- Automate detection of chlorophyll occurrence
- Overlay on Google Earth Ocean Color Maps
- Cross-compare with Ocean Color Imager products
- High HARP spectral resolution allows separation of absorption/emission features
- Baseline for sea surface albedo under clear and cloudy conditions, and in chlorophyll-rich vs. pure areas

Next steps

- Continue ocean color work (relate to satellite retrievals)
- Establish surface albedo data base, along with DC-3 work (CONUS)

- Re-save cloud retrievals at 1 second resolution
- Comparison with satellite cloud retrievals

- Application of spectral cloud retrieval to transmittance and reflectance data set (Samuel LeBlanc/Shi Song)
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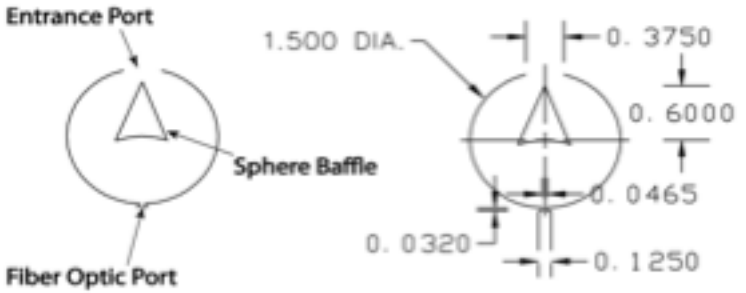
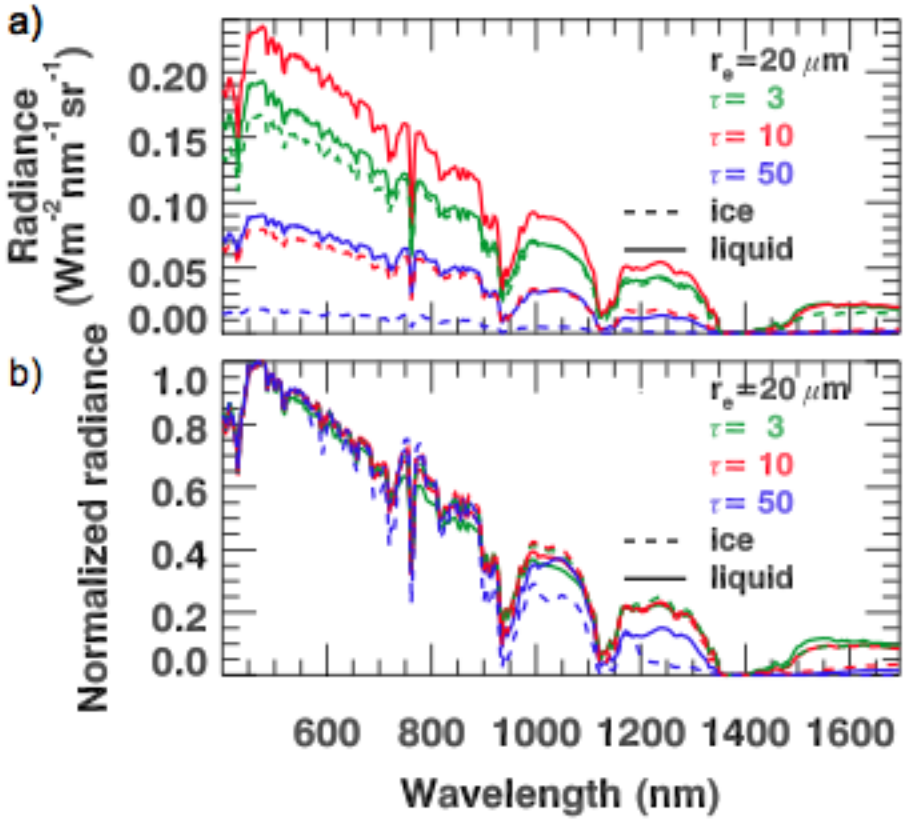
- Instrument improvement (CU/NCAR)

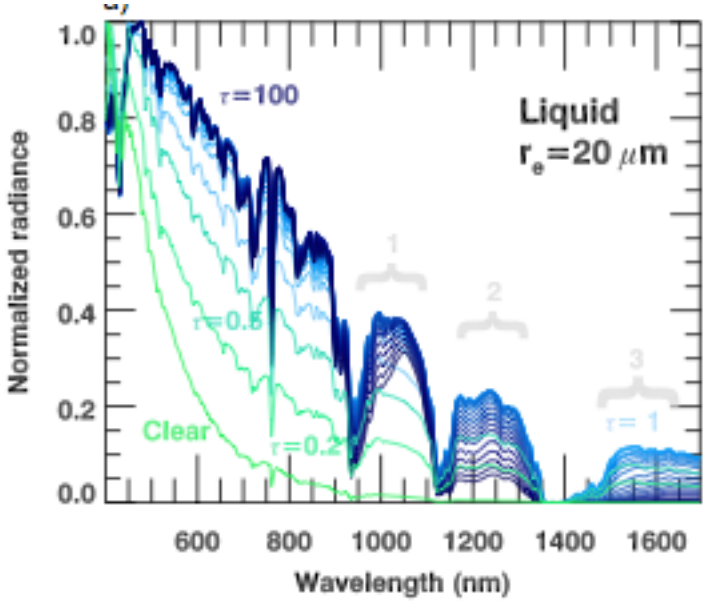


Spectral Cloud Retrieval

Use spectral shape, rather than absolute transmittance (reflectance) for cloud retrievals. Spectrally neutral biases in measurements do not affect this retrieval!



This work was, in part, inspired by TORERO data and developed by grad student Samuel LeBlanc, based on work previously done by Patrick McBride (2012).



LeBlanc et al., 2014

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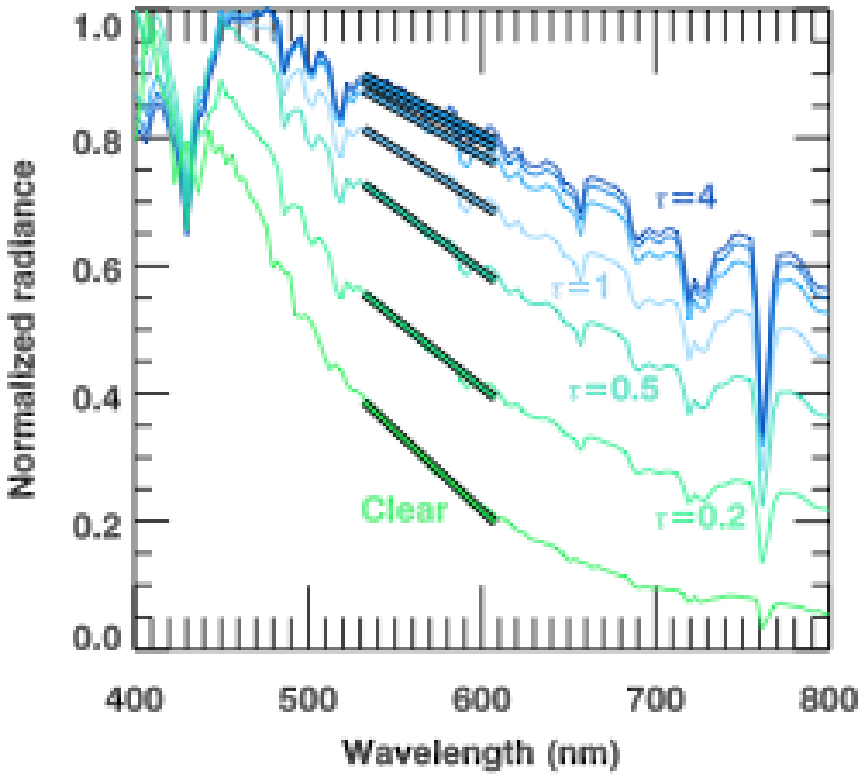
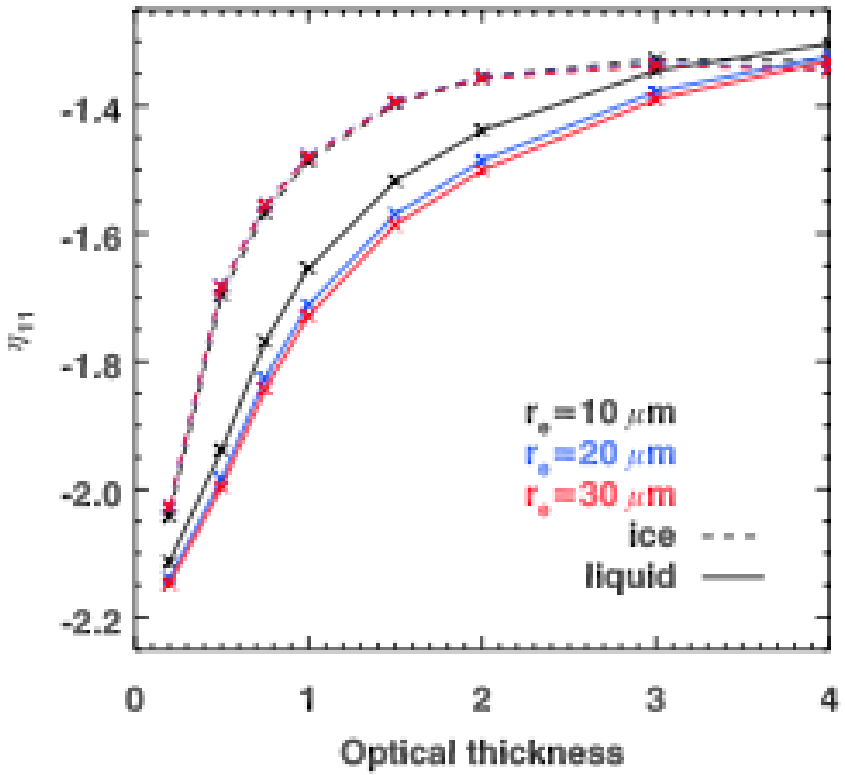
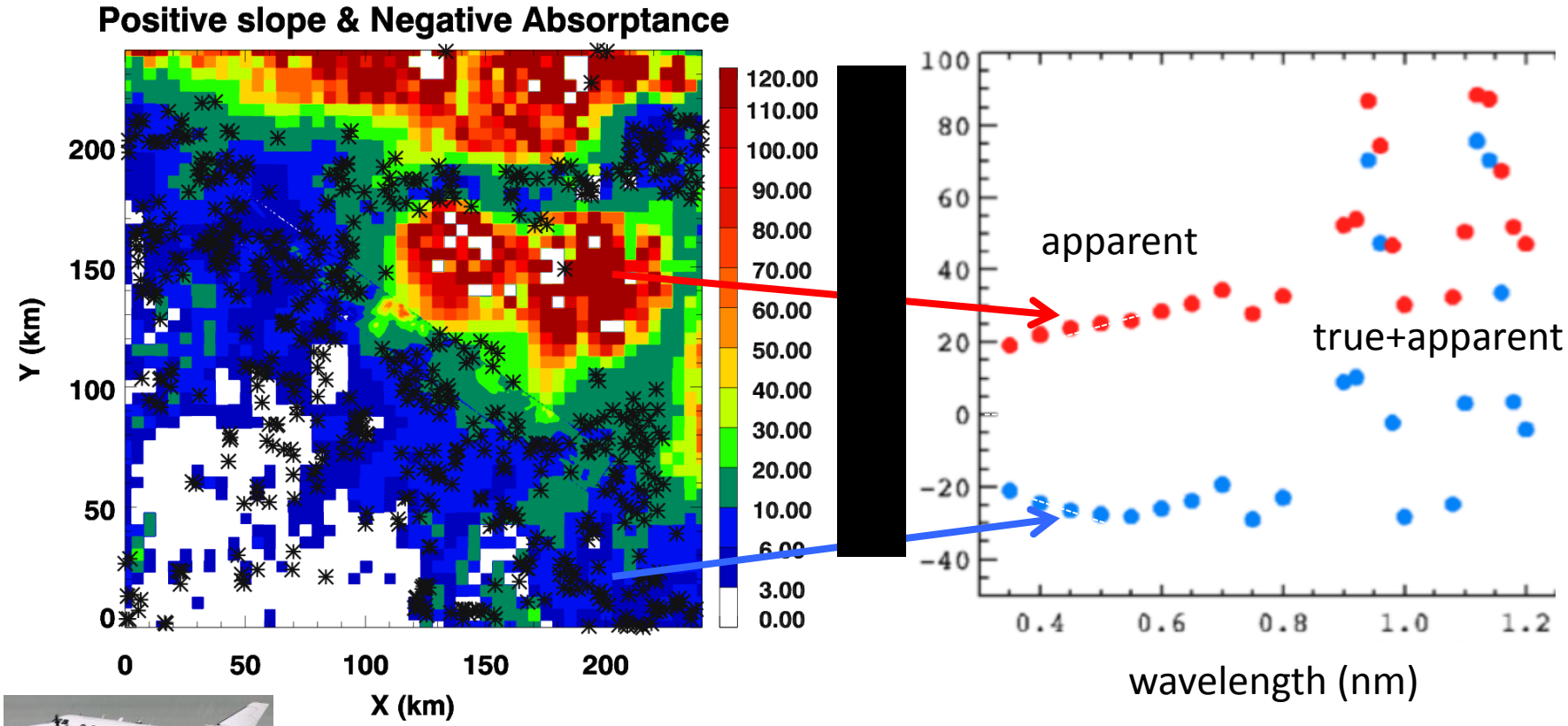


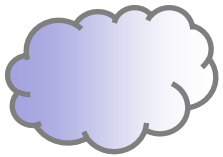


Applying this radiance-based retrieval to TORERO irradiance data may extend lower COD limit, at least for transmittance cases.

LeBlanc et al., 2014

“Colored” horizontal photon transport

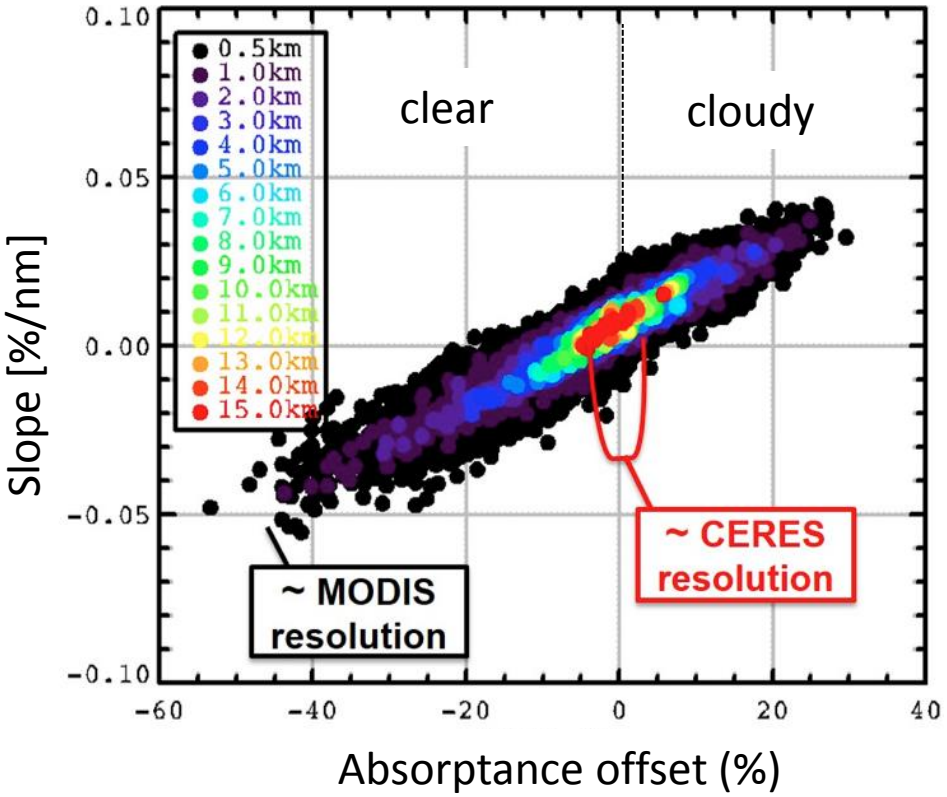


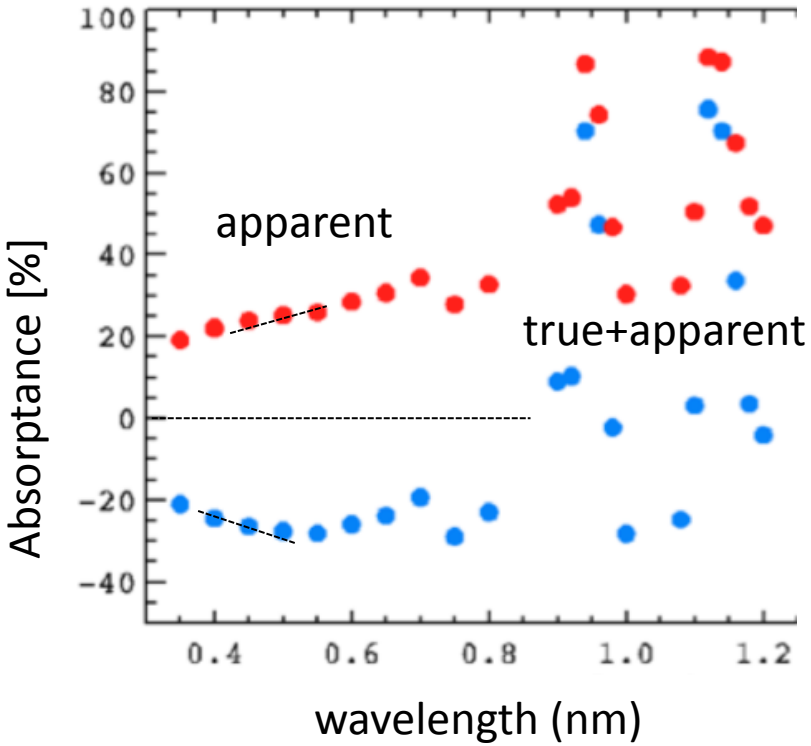


$$F^{above-below}_{ApparentAbsorptance}(\lambda) = \frac{F^{net,above}_{\lambda} - F^{net,below}_{\lambda}}{F^{\downarrow,above}_{\lambda}} \times 100\%$$

Song et al., 2014

Spatial-spectral correlation in multi-pixel domain





1. Spatial-spectral relationship holds for cascade of scales.
2. 3D effects are reduced by averaging
3. Collaboration with UW group

Song et al., 2014

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