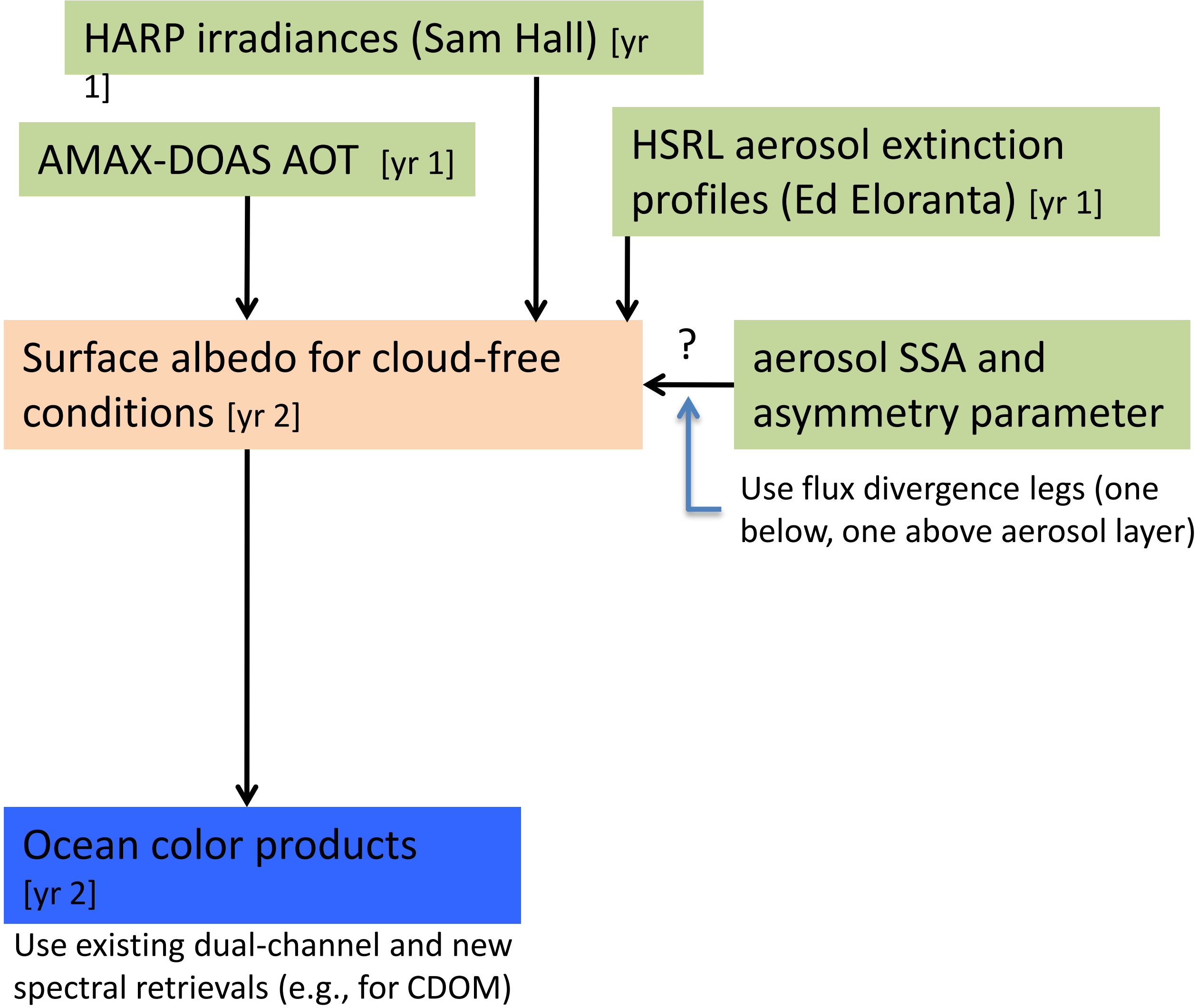
Using HARP measurements for deriving cloud, aerosol, and surface properties for TORERO

K. Sebastian Schmidt and Bruce Kindel

31 Oct 2011

Goals



HARP irradiances (Sam Hall) [yr 1]

AMAX-DOAS AOT [yr 1]

HSRL aerosol extinction profiles (Ed Eloranta) [yr 1]

Surface albedo for cloud-free conditions [yr 2]

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aerosol SSA and asymmetry parameter

Use flux divergence legs (one below, one above aerosol layer)

Ocean color products [yr 2]

Use existing dual-channel and new spectral retrievals (e.g., for CDOM)

Statement of work:

Yr 1: Experiment (no participation) – collect HARP irradiances.

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(1) Monitor ocean-surface organic activity

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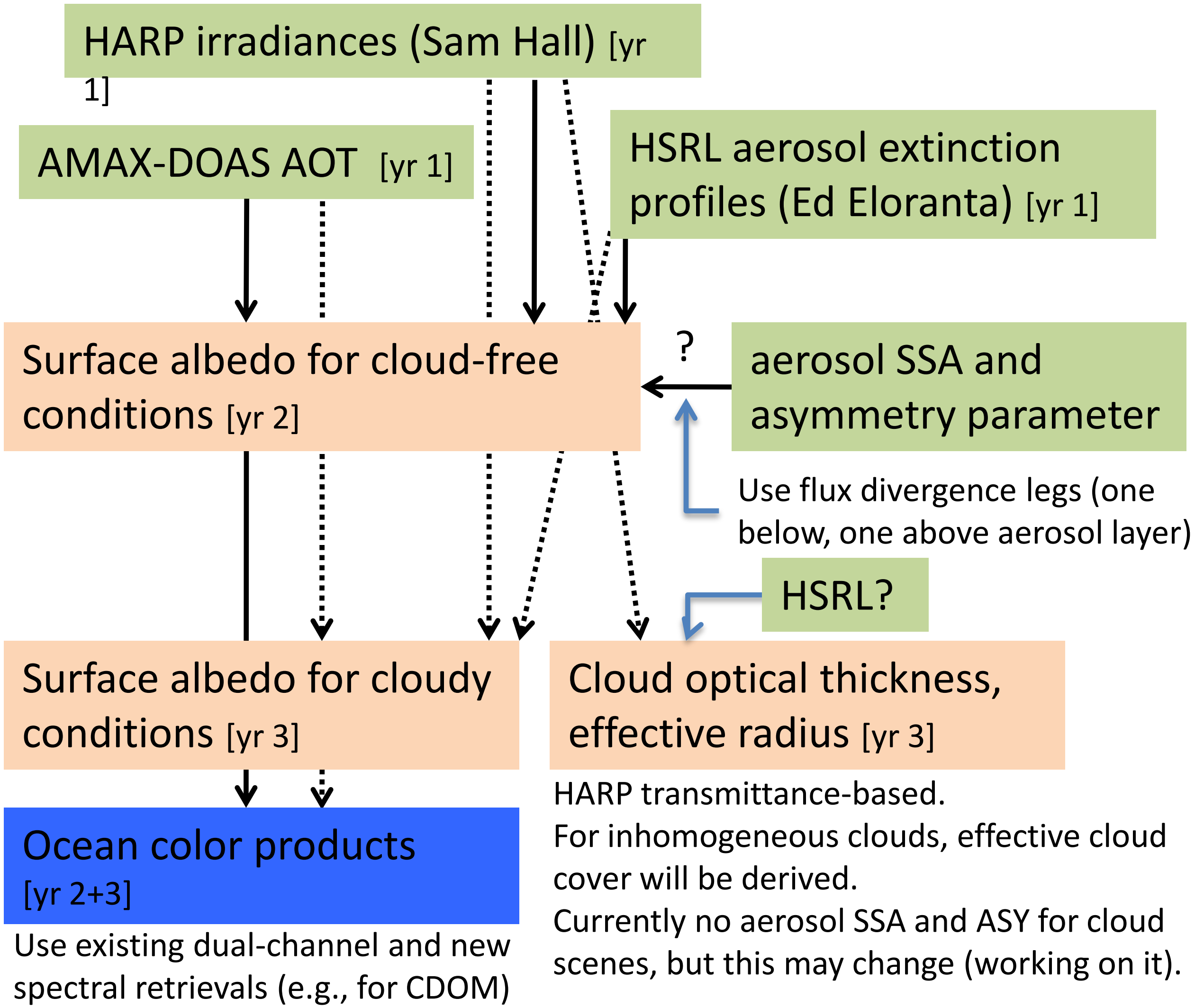

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Surface albedo for cloudy conditions [yr 3]

Cloud optical thickness, effective radius [yr 3]

HARP transmittance-based.
For inhomogeneous clouds, effective cloud cover will be derived.
Currently no aerosol SSA and ASY for cloud scenes, but this may change (working on it).

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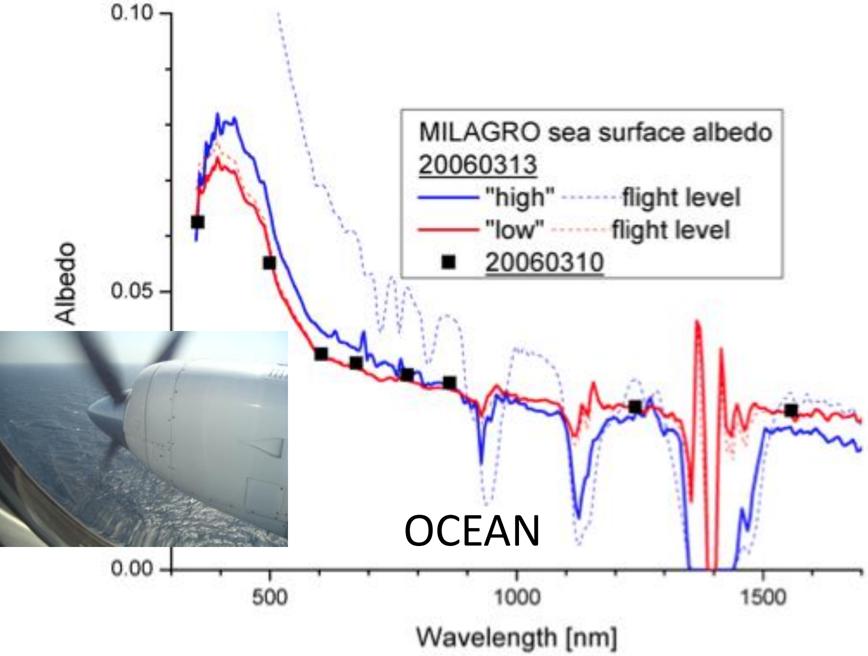
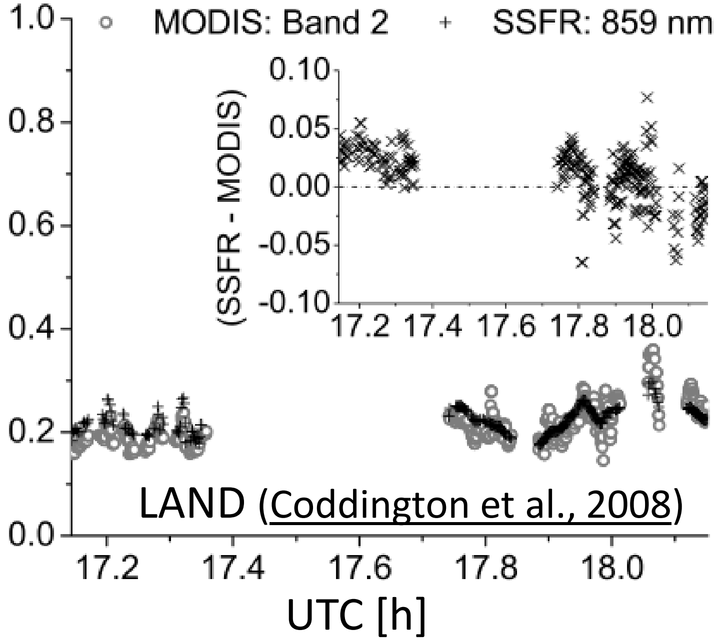
Yr 3: Extend the work from yr 2 to cloudy conditions and retrieve cloud optical properties, surface albedo, and ocean color products simultaneously.

(1) Monitor ocean-surface organic activity
(2) Study impact of clouds on ocean color and aerosol retrievals

How do we derive surface albedo?



OCEAN



LAND (Coddington et al., 2008)

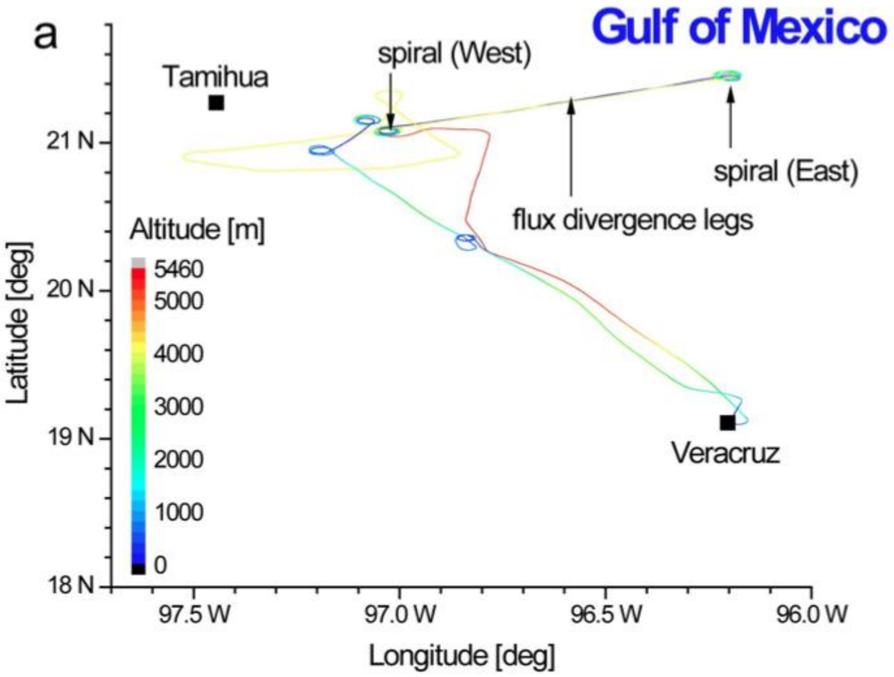
Overflying the ocean at high and low altitude allows us to check the performance of our atmospheric correction. Dotted lines show flight level albedo; solid lines derived surface albedo from high level (blue), and low level (red).

We need aerosol optical thickness, single scattering albedo, and asymmetry parameter as input. We will get extinction profiles / optical thickness from HSRL/AMAX-DOAS.

For SSA and ASY, we will use parameterizations…

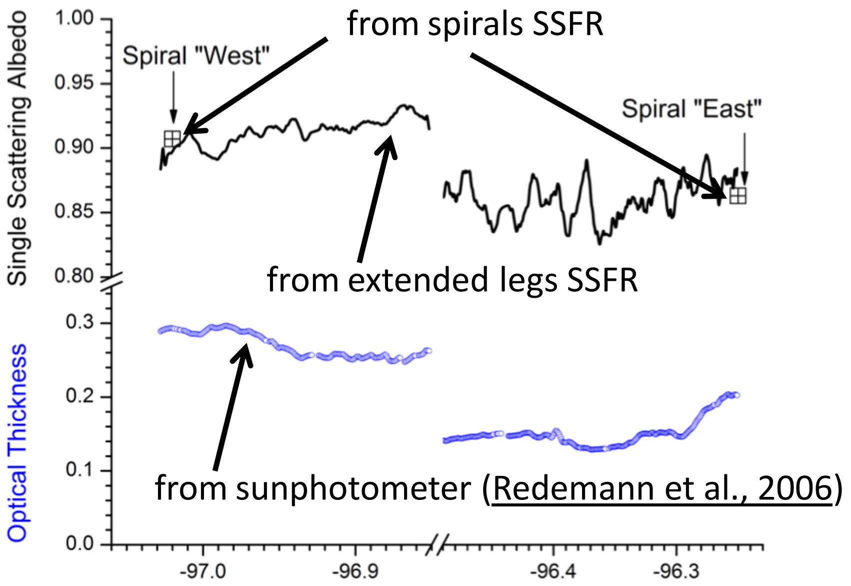
…or, if we have high and low level measurements of the same scene, we can also derive SSA and ASY from HARP measurements (next slide).

How do we derive aerosol optical properties?



Obtain SSA, ASY, and surface albedo from irradiance pairs (up and dn) above, and below (within) the aerosol layer, given the extinction profile.

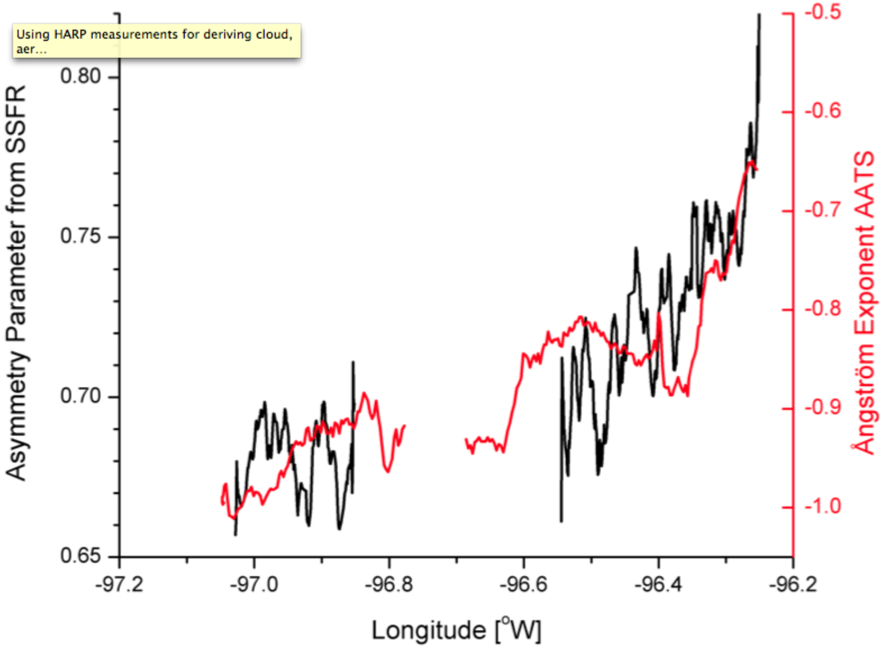
Can get these pairs from (a) spirals through layers or (b) extended legs above/below layer (Schmidt et al., ACP, 2010).



from spirals SSFR

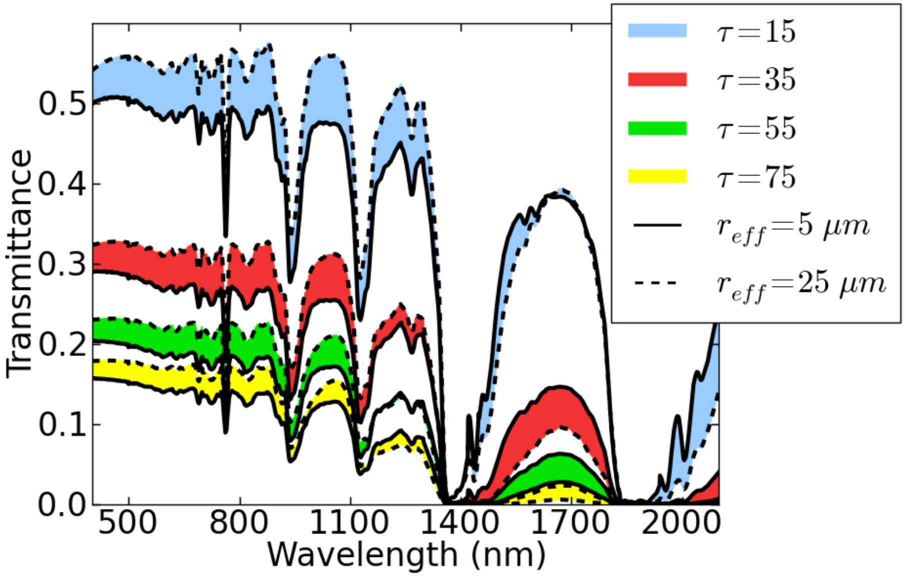
from extended legs SSFR

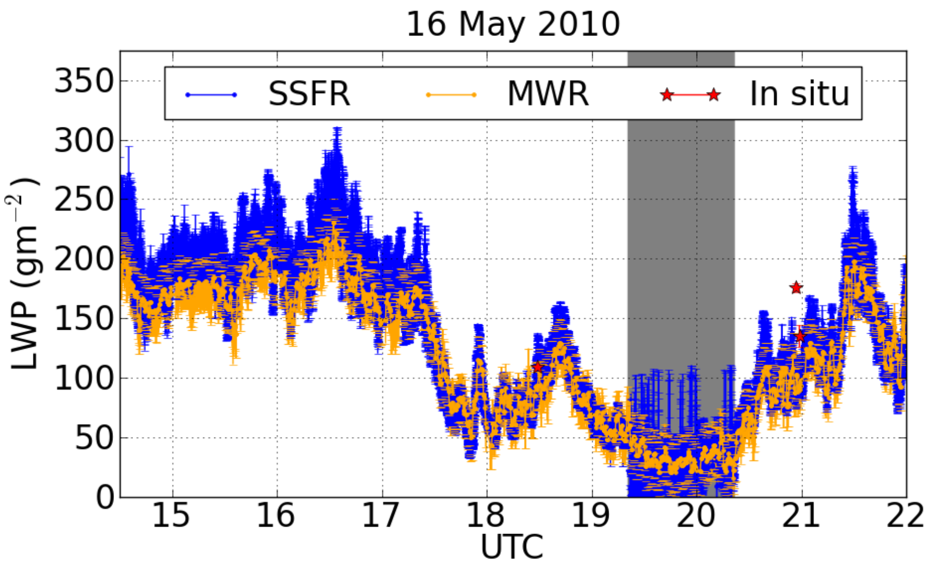
from sunphotometer (Redemann et al., 2006)



Using HARP measurements for deriving cloud, aer...

How do we derive cloud properties from transmittance?





Derive optical thickness from transmitted irradiance (radiance).

It is usually hard to also get effective radius and thus liquid (ice) water path, but we have developed a new spectral retrieval that can do it (McBride et al., 2011).

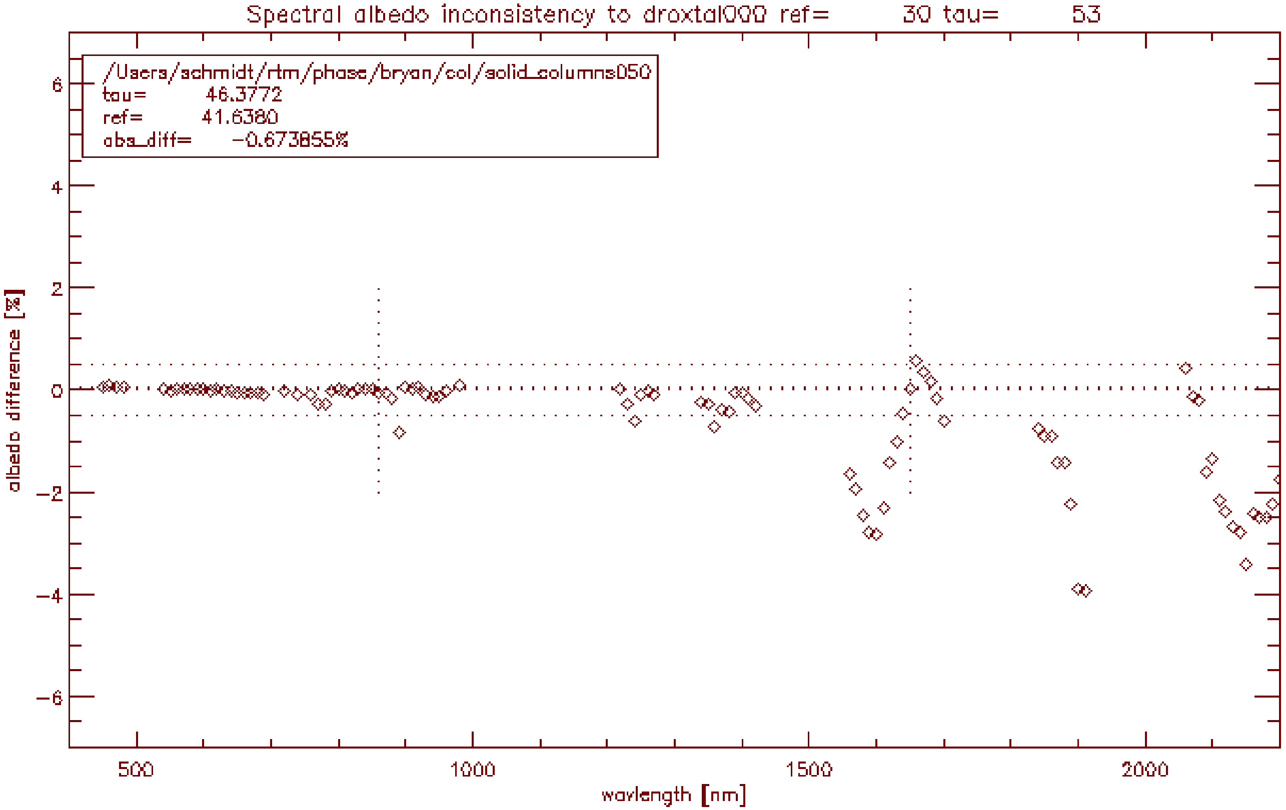
This retrieval works for optical thickness above 3. Together with HSRL, we can cover the whole cloud optical thickness range.

The impact of cloud inhomogeneities and crystal habit for ice clouds is an ongoing research topic in our group (Kindel et al., 2010).

We have used these retrievals for extended cal/val efforts (collaboration Brad Pierce).

In-situ data courtesy Sara Lance / NOAA
Microwave data courtesy Chris Fairall; Dan Wolfe / NOAA

How do we derive cloud properties from reflectance?



spectral consistence

$\{R_{860\text{ nm}}\ ;\ R_{1600\text{ nm}}\}$

$\downarrow$

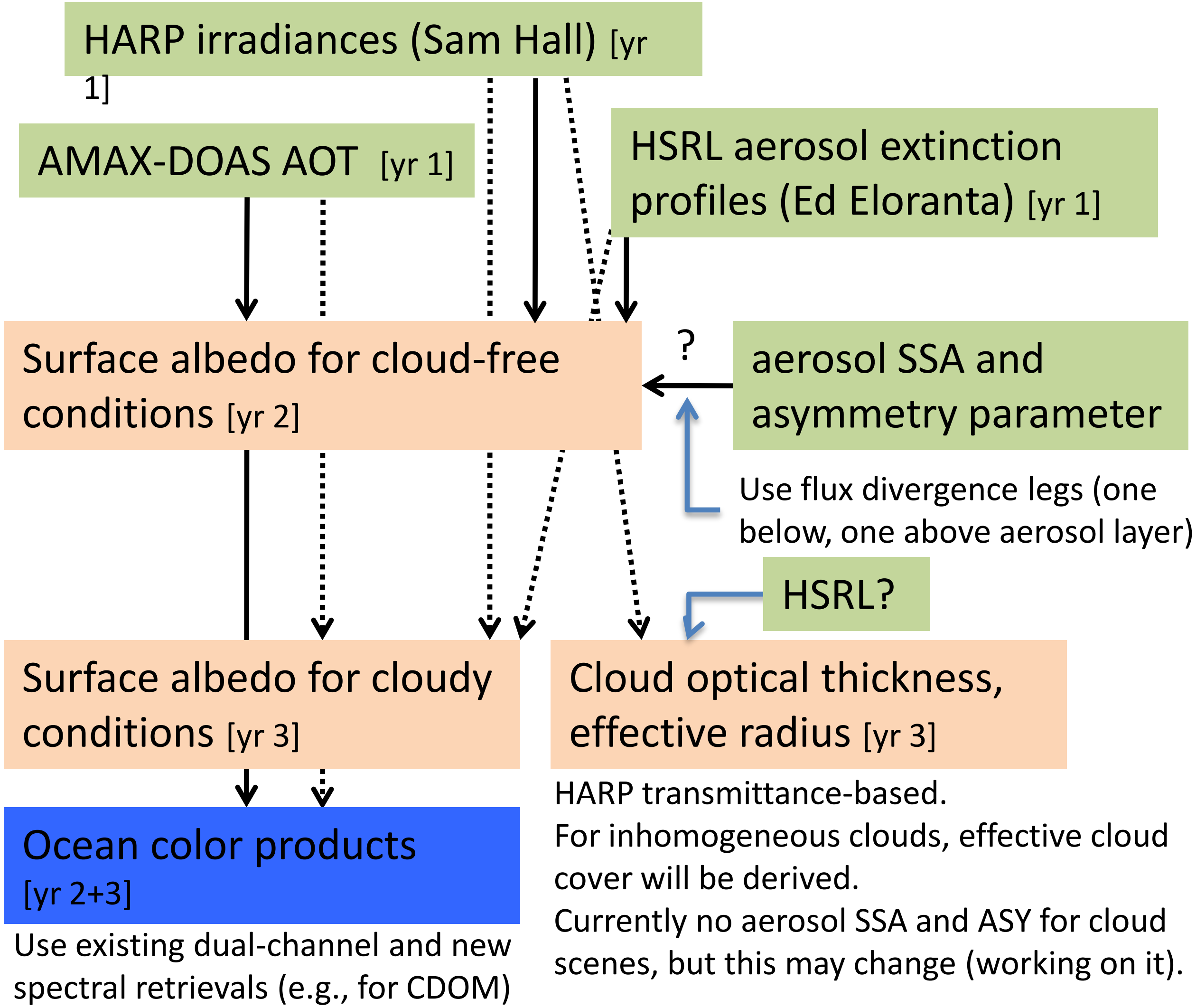
$\{\tau\ ;\ r_{\text{eff}}\}$ $\{h\ ;\ \alpha\}$ gas profiles

$\downarrow$

$\{R_{350\text{ nm}} - R_{3800\text{ nm}}\}$

Test adequacy of single scattering model (habit) in Cirrus clouds with spectral consistence. There may also be a correlation between spectral shape of cloud albedo and spatial inhomogeneity, as well as a capability for detecting mixed-phase clouds (ongoing research).

Summary



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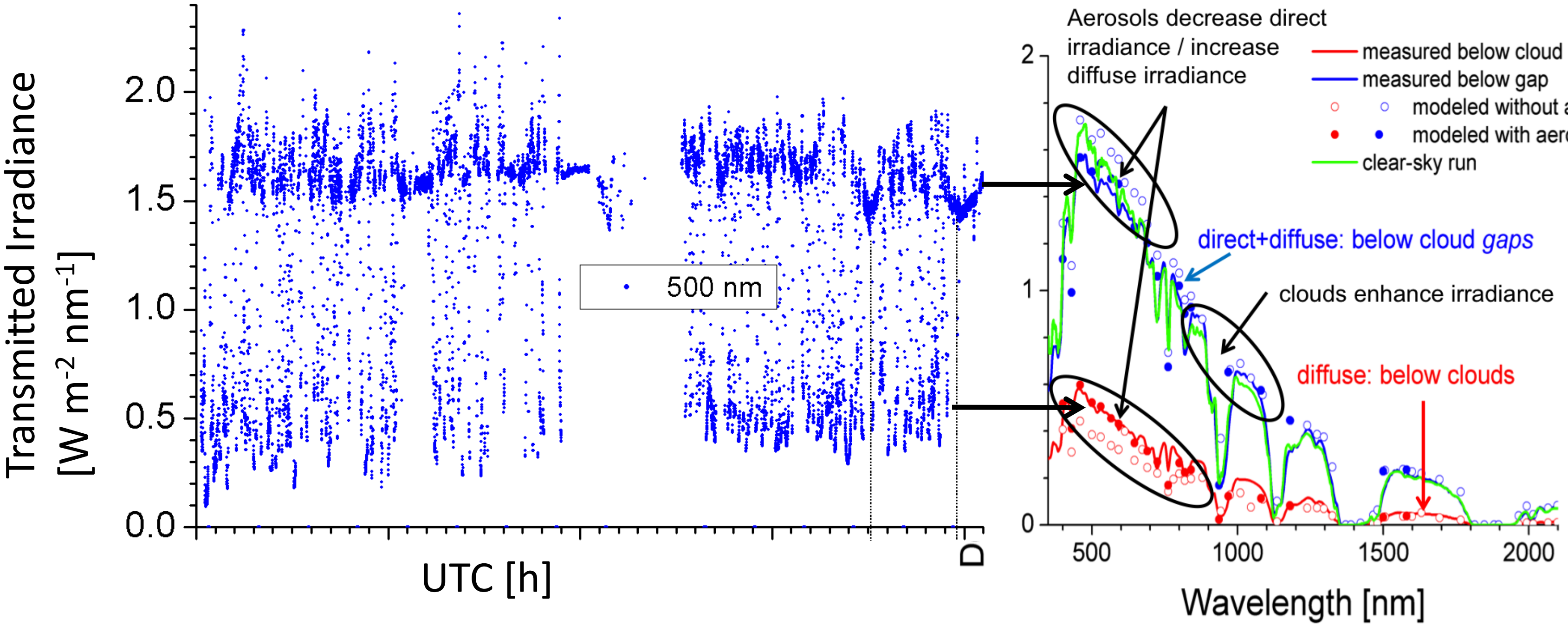
How do we handle aerosol-immersed broken clouds?



Aerosols decrease direct irradiance / increase diffuse irradiance

direct+diffuse: below cloud *gaps*

clouds enhance irradiance

diffuse: below clouds

Handle cloud gaps (diffuse irradiance) and clouds (direct beam) *separately*. Use 3D model to understand the different effects of cloud inhomogeneities (spectrally-dependent net horizontal photon transport), aerosols, and the surface.

This is mainly done within two NASA projects (not scope of TORERO):

(a) remote sensing theory – retrieval of cloud/aerosol properties from spectral radiance

(b) OCO project: Impact of cloud inhomogeneities on CO_2 retrievals.

Both could also benefit the TORERO science team.