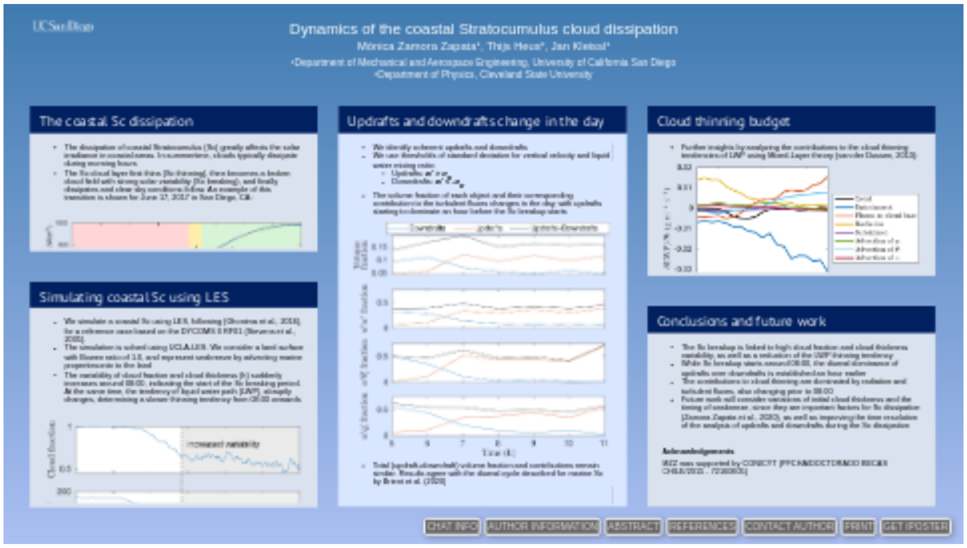
Dynamics of the coastal Stratocumulus cloud dissipation



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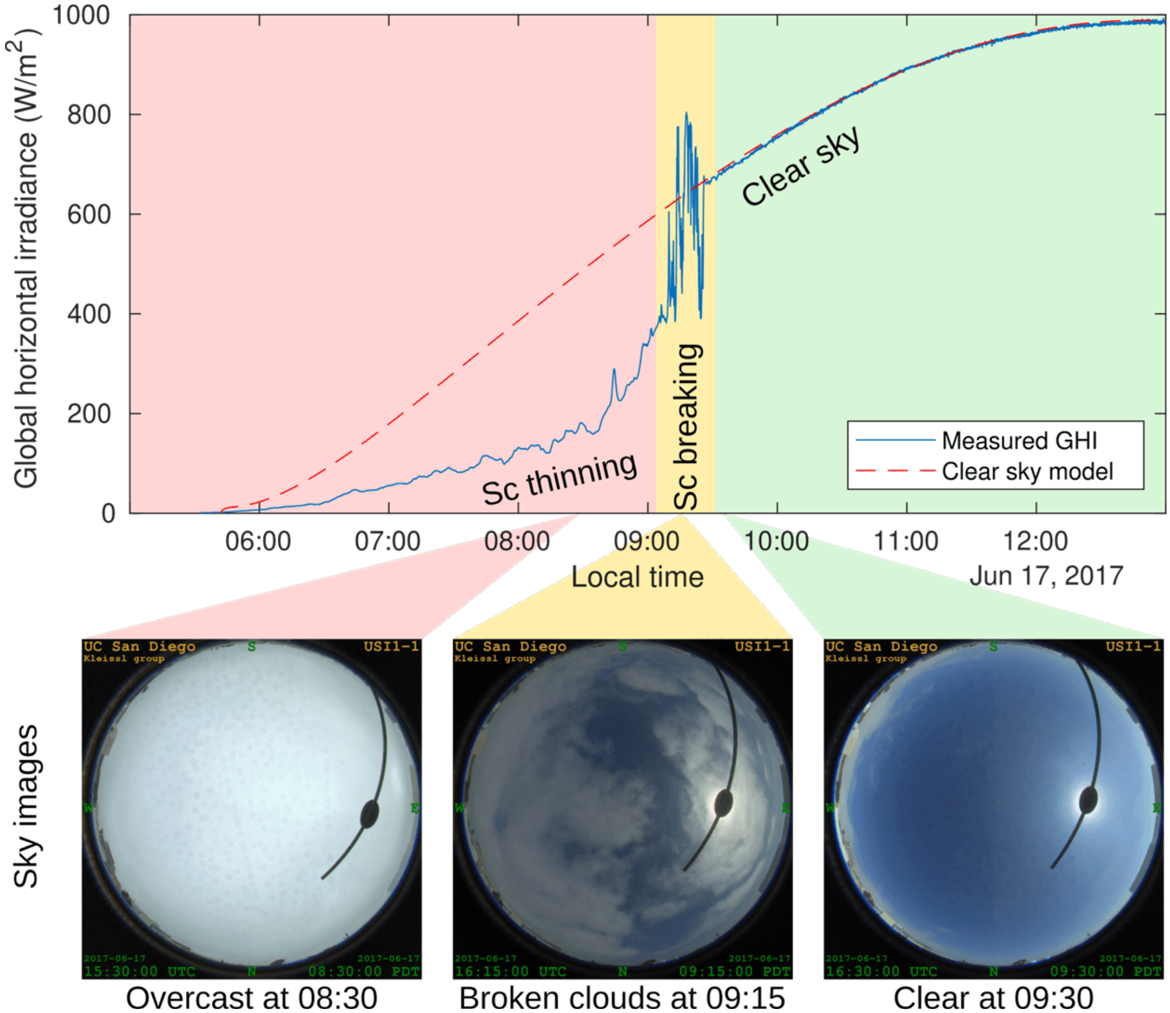
THE COASTAL SC DISSIPATION

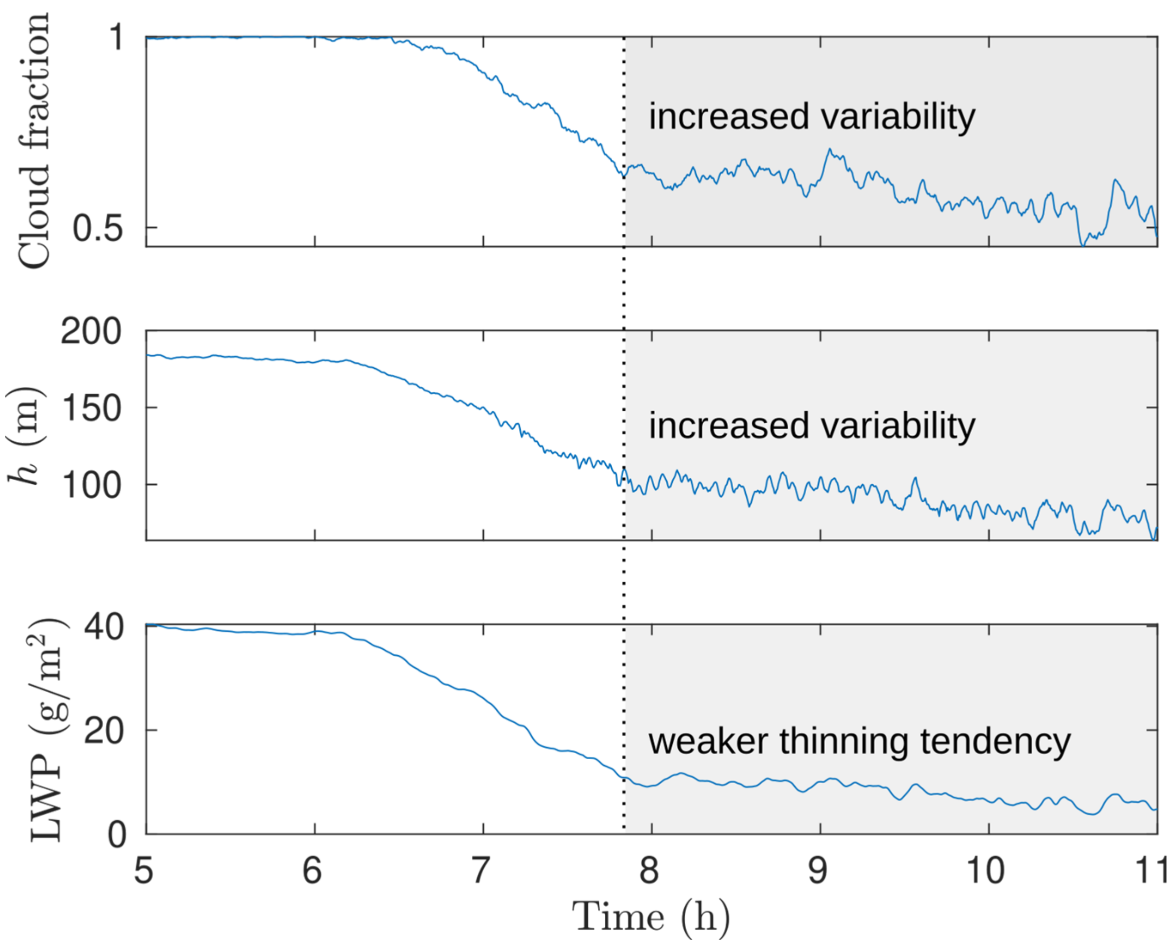
- The dissipation of coastal Stratocumulus (Sc) greatly affects the solar irradiance in coastal areas. In summertime, clouds typically dissipate during morning hours
- The Sc cloud layer first thins (Sc thinning), then becomes a broken cloud field with strong solar variability (Sc breaking), and finally dissipates and clear sky conditions follow. An example of this transition is shown for June 17, 2017 in San Diego, CA:



- Greater insight into the dissipation transition can help to improve weather and solar forecasts

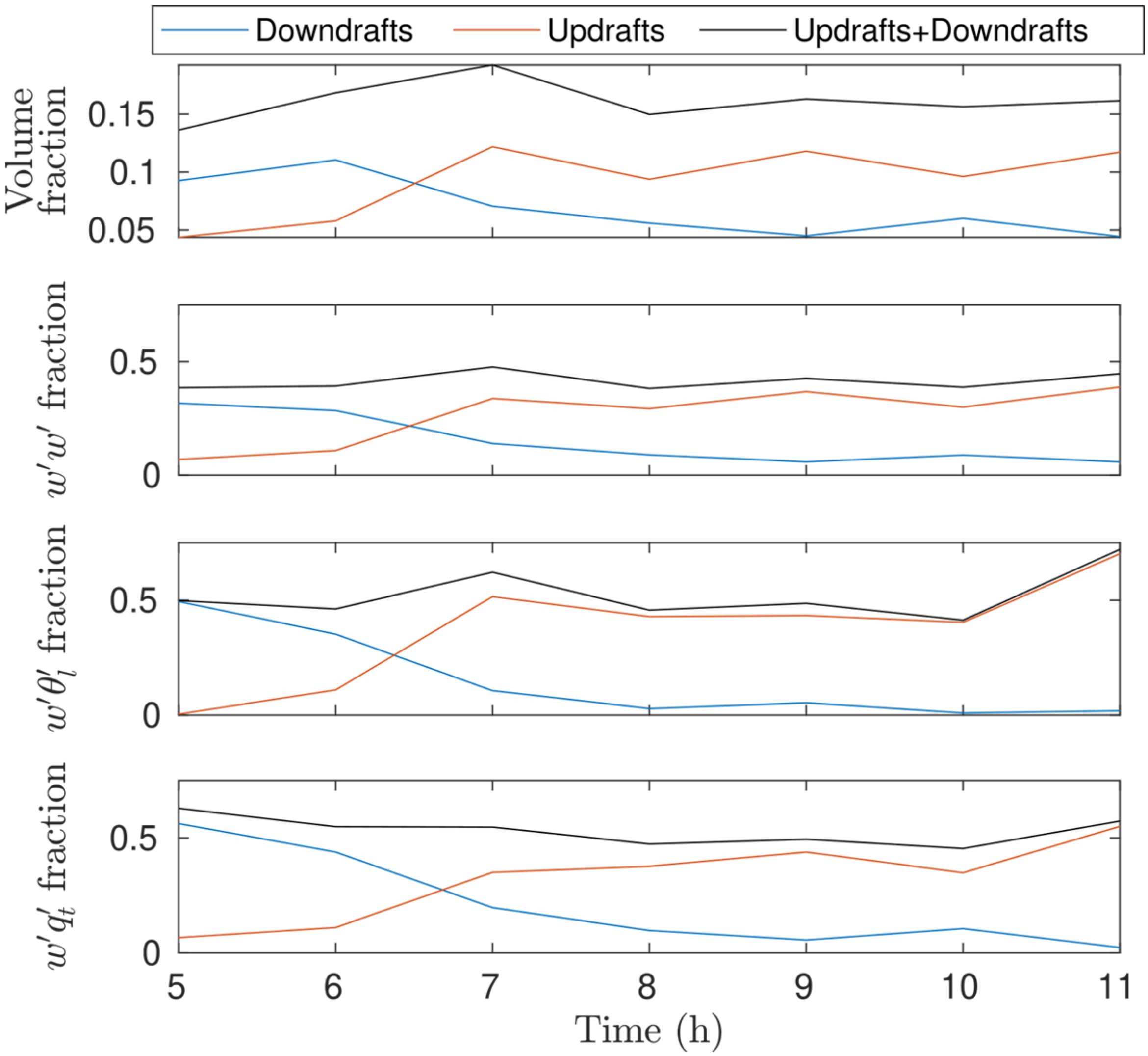
SIMULATING COASTAL SC USING LES

- We simulate a coastal Sc using LES, following (Ghonima et al., 2016), for a reference case based on the DYCOMS II RF01 (Stevens et al., 2005).
- The simulation is solved using UCLA-LES. We consider a land surface with Bowen ratio of 1.0, and represent seabreeze by advecting marine propertiesonto to the land
- The variability of cloud fraction and cloud thickness (h) suddenly increases around 08:00, indicating the start of the Sc breaking period. At the same time, the tendency of liquid water path (LWP), abruptly changes, determining a slower thinning tendency from 08:00 onwards



UPDRAFTS AND DOWNDRAFTS CHANGE IN THE DAY

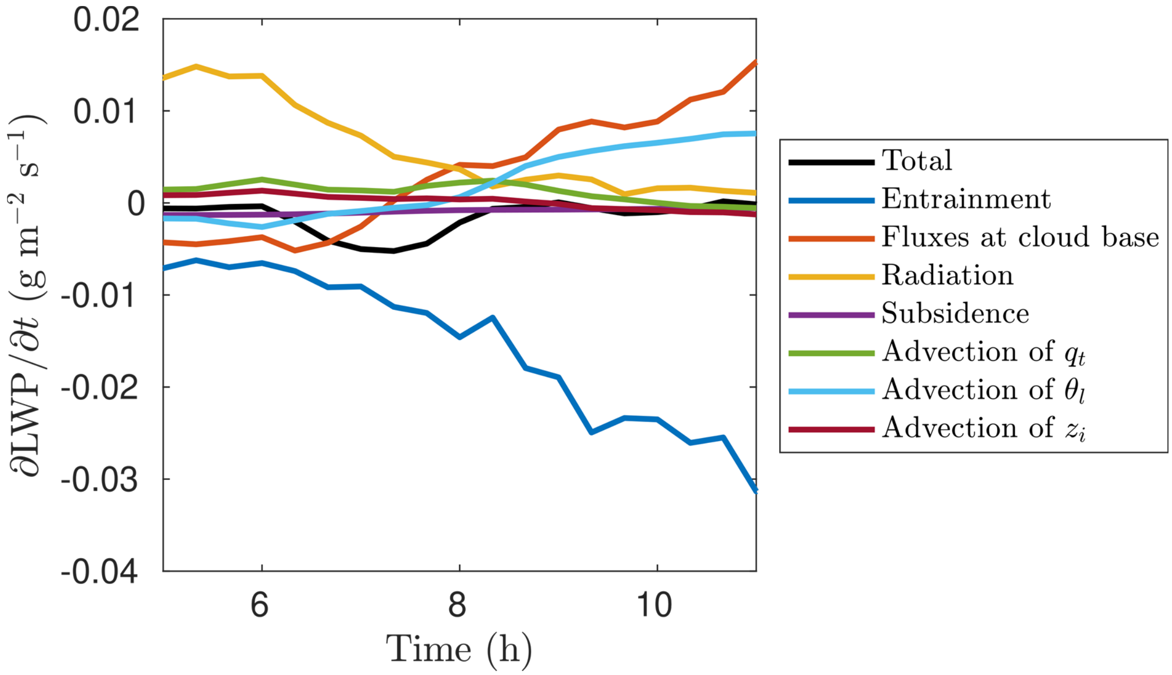
- We identify coherent updrafts and downdrafts
- We use thresholds of standard deviation for vertical velocity and liquid water mixing ratio:
  - Updrafts: $w' > \sigma_w$
  - Downdrafts: $w' < -\sigma_w$
- The volume fraction of each object and their corresponding contribution to the turbulent fluxes changes in the day, with updrafts starting to dominate an hour before the Sc breakup starts



- Total (updraft+downdraft) volume fraction and contributions remain similar. Results agree with the diurnal cycle described for marine Sc by Brient et al. (2020)

CLOUD THINNING BUDGET

- Further insights by analyzing the contributions to the cloud thinning tendencies of LWP using Mixed-Layer theory (van der Dussen, 2013):



- Radiation and turbulent fluxes at cloud base dominate the contributions to cloud thinning, changing their dominance prior to 08:00 (when the breakup starts)

CONCLUSIONS AND FUTURE WORK

- The Sc breakup is linked to high cloud fraction and cloud thickness variability, as well as a reduction of the LWP thinning tendency
- While Sc breakup starts around 08:00, the diurnal dominance of updrafts over downdrafts is established an hour earlier
- The contributions to cloud thinning are dominated by radiation and turbulent fluxes, also changing prior to 08:00
- Future work will consider variations of initial cloud thickness and the timing of seabreeze, since they are important factors for Sc dissipation (Zamora Zapata et al., 2020), as well as improving the time resolution of the analysis of updrafts and downdrafts during the Sc dissipation

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ABSTRACT

Coastal Stratocumulus clouds (Sc) can greatly impact the available solar radiation in areas like southern California. These clouds usually dissipate during the morning, as surface fluxes increase in the day. The dissipation process begins by the thinning of the cloud layer, that then becomes a broken cloud field until the clouds completely dissipate. A better understanding of the process could improve predictions of dissipation time and solar variability for this type of clouds. We investigate the evolution of a broken cloud field using LES simulations of coastal Sc clouds over Southern California (Ghonima et al, JAS 2016). We identify and characterize coherent updrafts, downdrafts, and cloud elements using flow field variables (vertical velocity and liquid water mixing ratio). The cloud layer is observed to become a broken cloud field around hour 8 of the simulation, after which the thinning tendency strongly diminishes and the variability of cloud fraction, cloud thickness, and liquid water path suddenly increases. The few cloud elements remaining at noon are found to be located close to cloud base, unlike at night, when they are distributed throughout the whole cloud layer. The largest updrafts and downdrafts contribute to a large portion of the turbulent fluxes along the day (on average, 40% of vertical velocity variance and 48% of the buoyancy flux), and their relative contribution changes during the day as updrafts become stronger and downdrafts weaken around noon.

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