Frontiers in mesoscale organization of boundary-layer clouds

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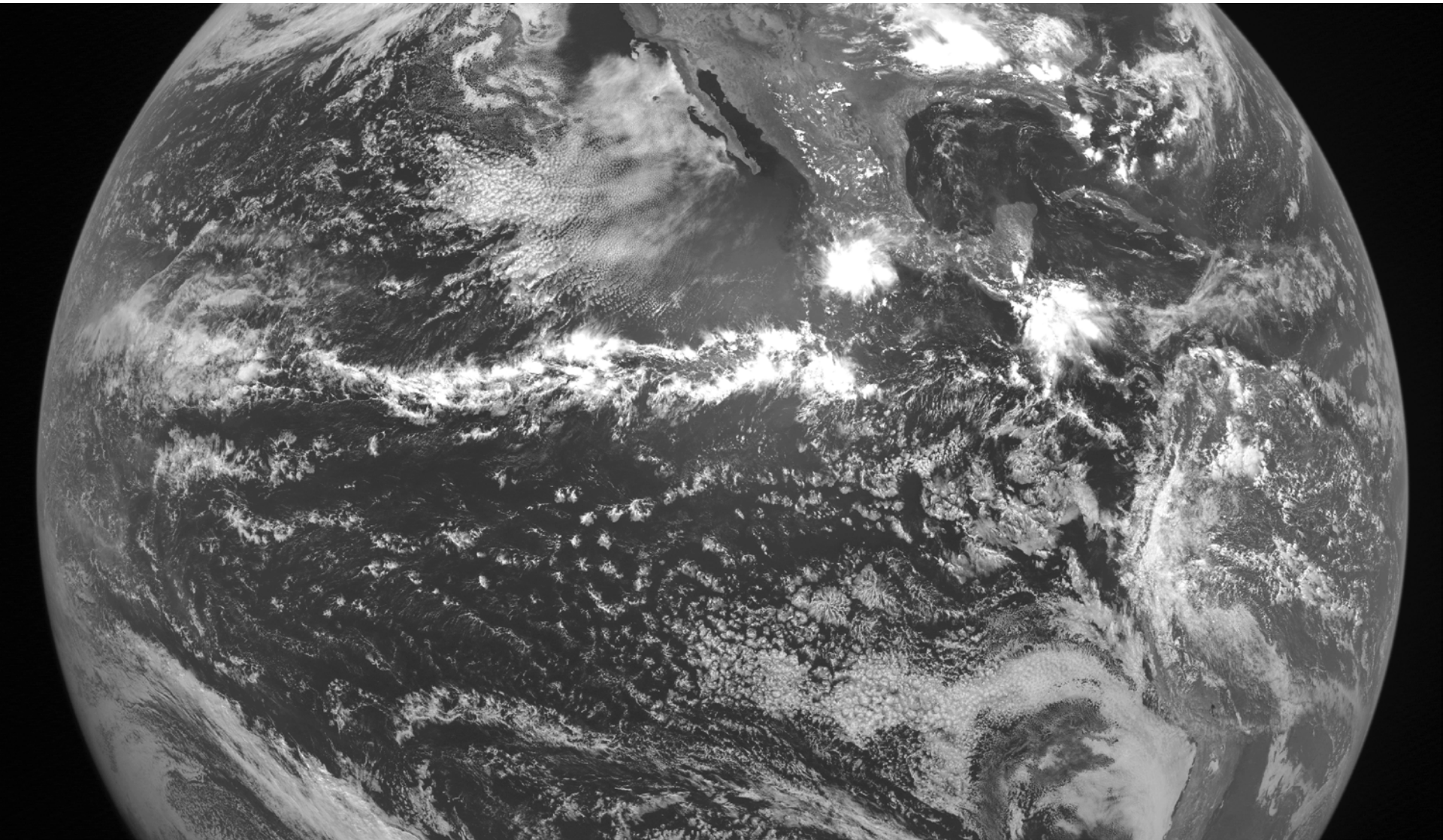
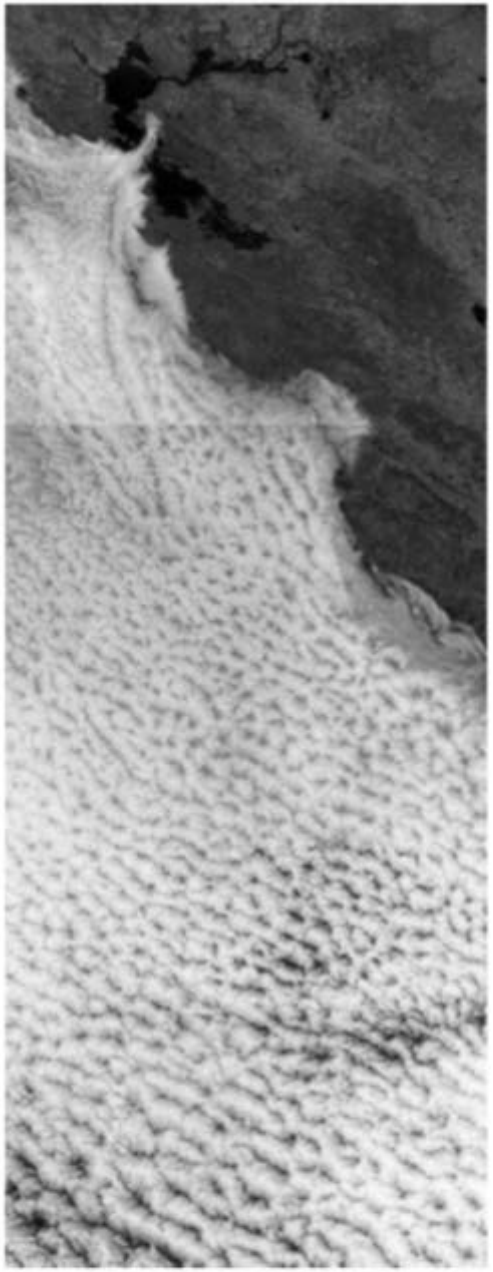


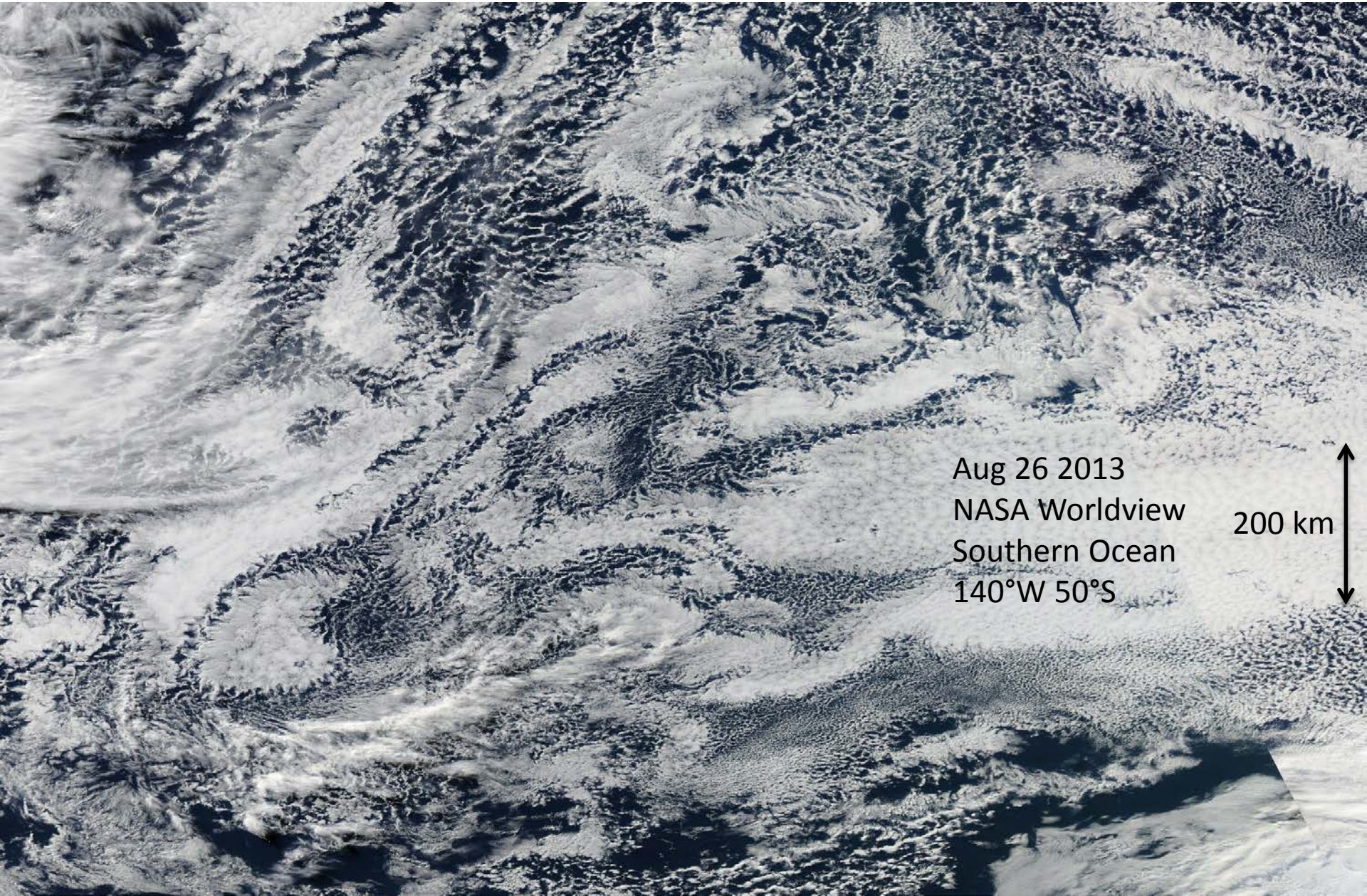
Open and closed cells

https://www.st-andrews.ac.uk/~dlb2/climate/lapserates.html

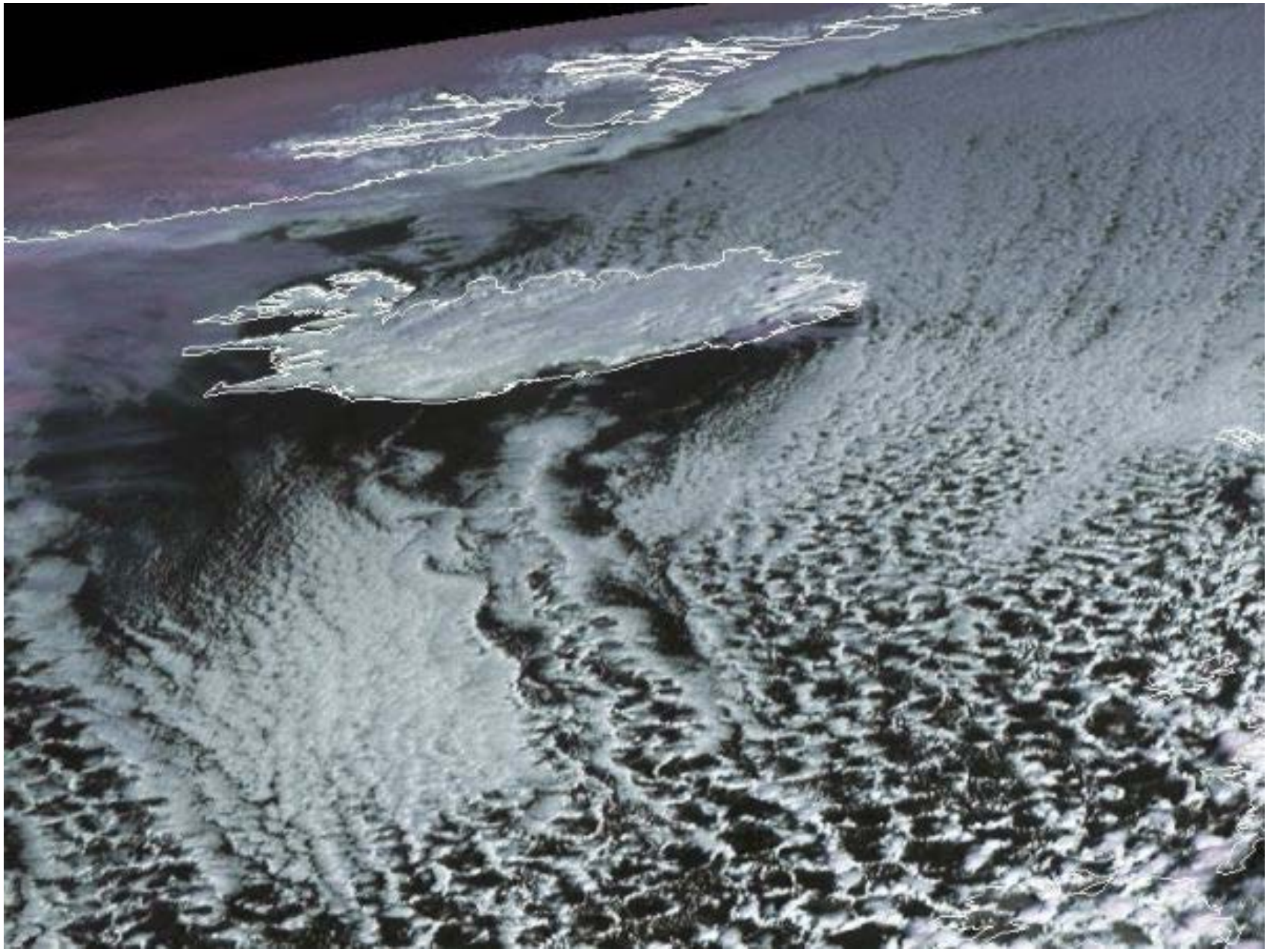


. Landsat satellite image (domain size about 200 × 600 km²)
stratocumulus off the coast of California 14 Jul 1987. The
ps are at 500 ~ 1000 m whereas the convective cells have
ntal dimension of about 10 km. The aspect ratio of the con-
cells is thus much larger than 1.

Interspersed open and closed cells…why?



Cold air outbreaks



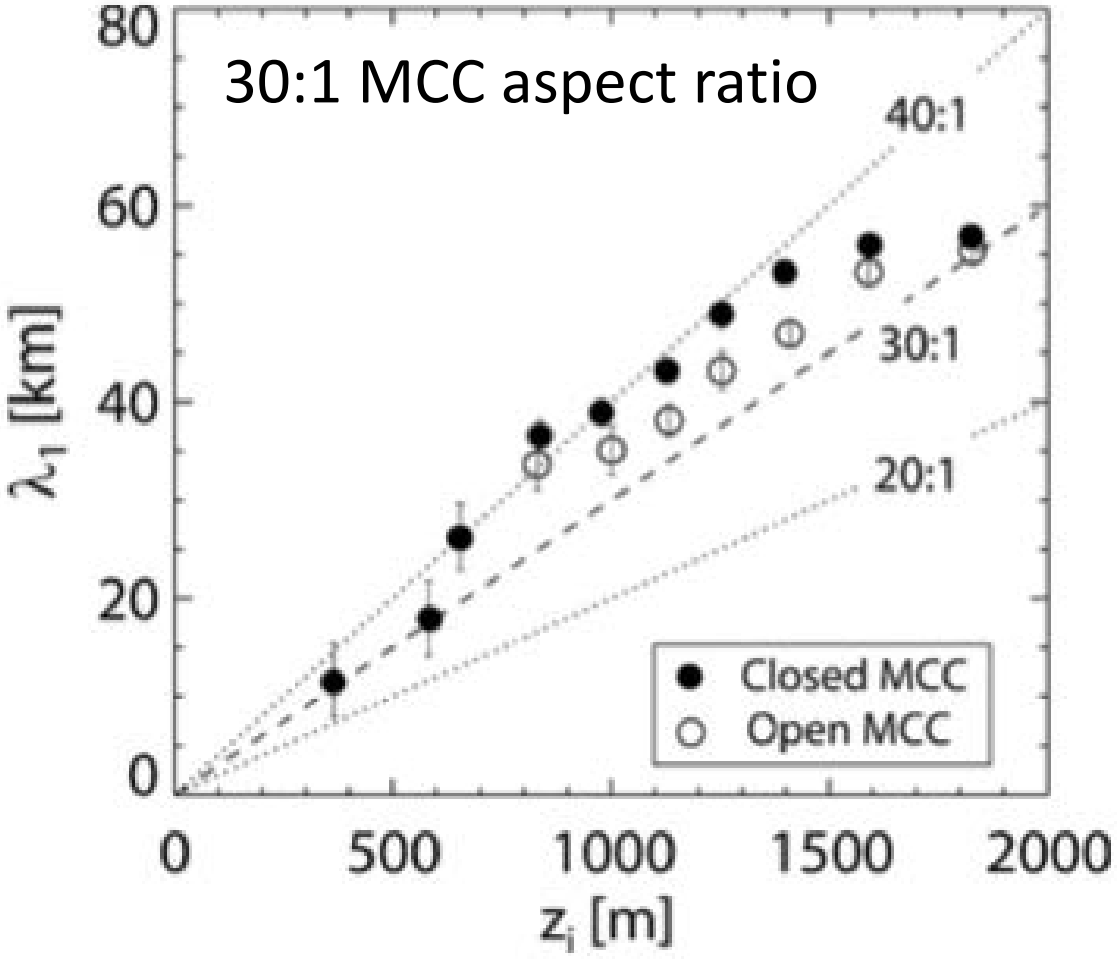
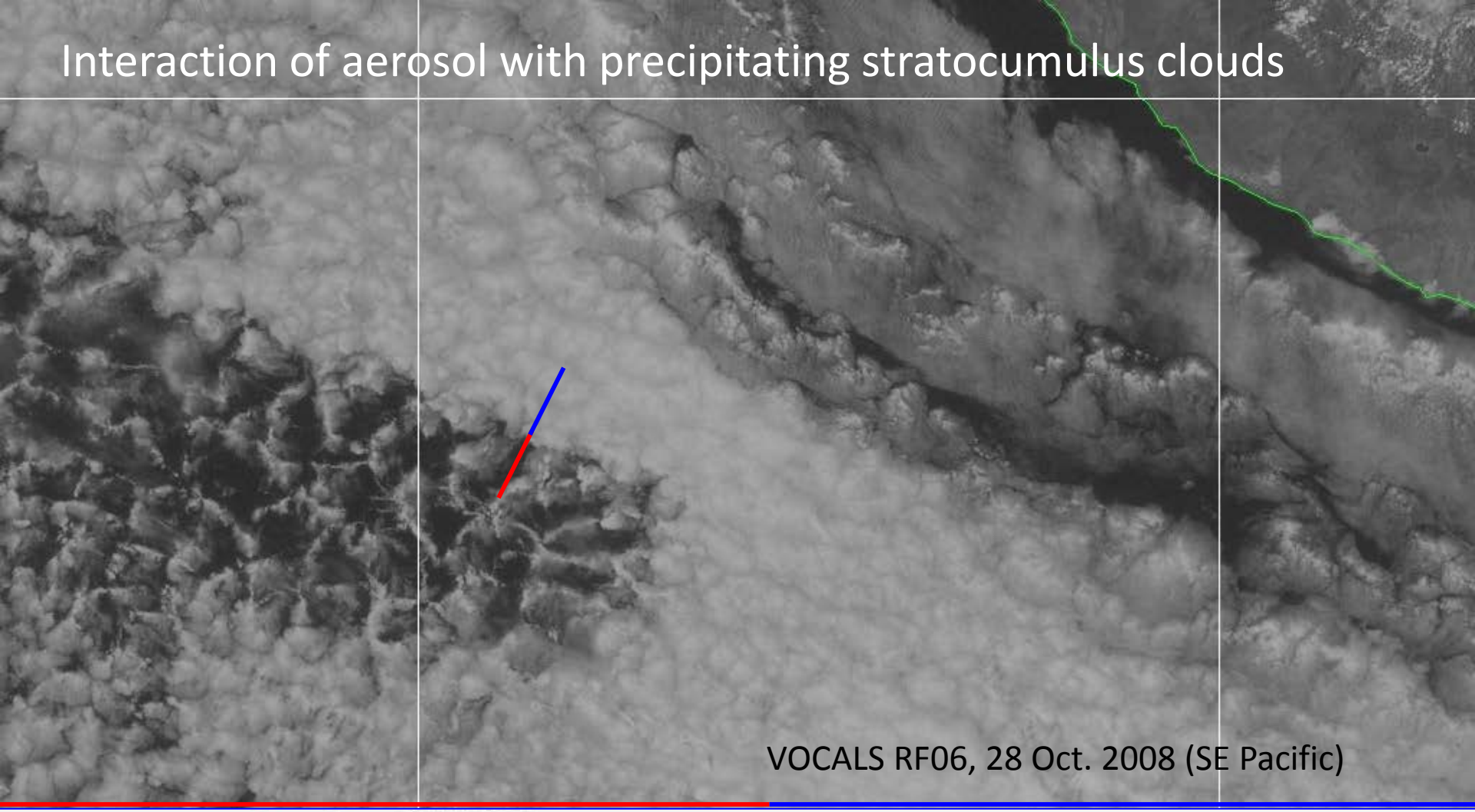


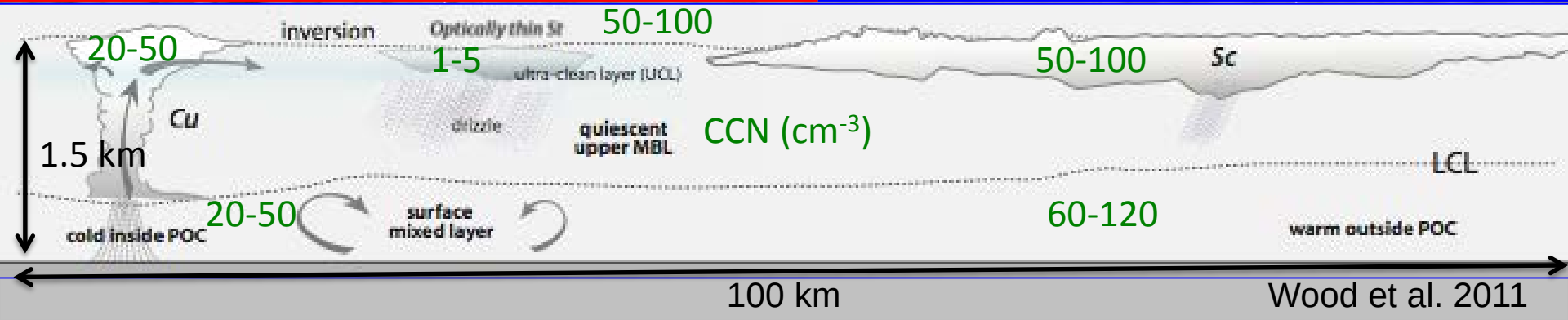
FIG. 17. Median characteristic cell length scale λ_1 binned by z_i for all MODIS scenes (solid circles) over the NE and SE Pacific. The dotted lines denote aspect ratios of 20:1, 30:1, and 40:1. Error bars indicate the approximate sampling error in the median. The solid line indicates the fit described in the text.

Wood and Hartmann 2006

Interaction of aerosol with precipitating stratocumulus clouds



VOCALS RF06, 28 Oct. 2008 (SE Pacific)



Wood et al. 2011

LES can simulate open and closed MCC

- cell sizes grow with time
- can also do aerosol-cloud-rain interaction and POCs (Wang and Feingold 2009, Kazil et al. 2011, Berner et al. 2013)

Schroeter et al. 2005

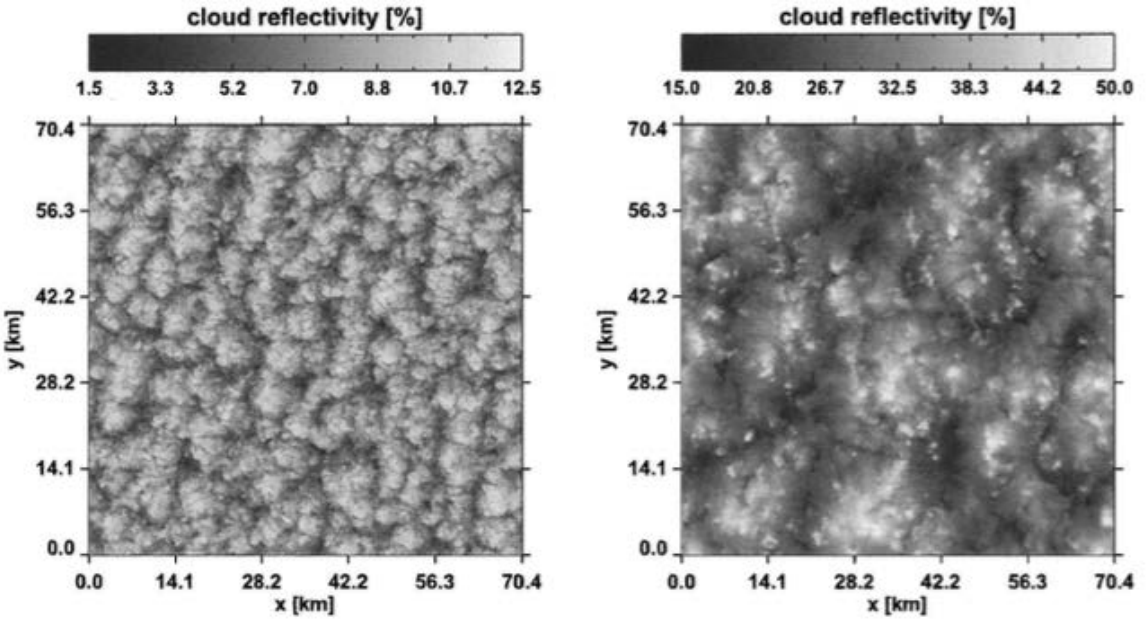
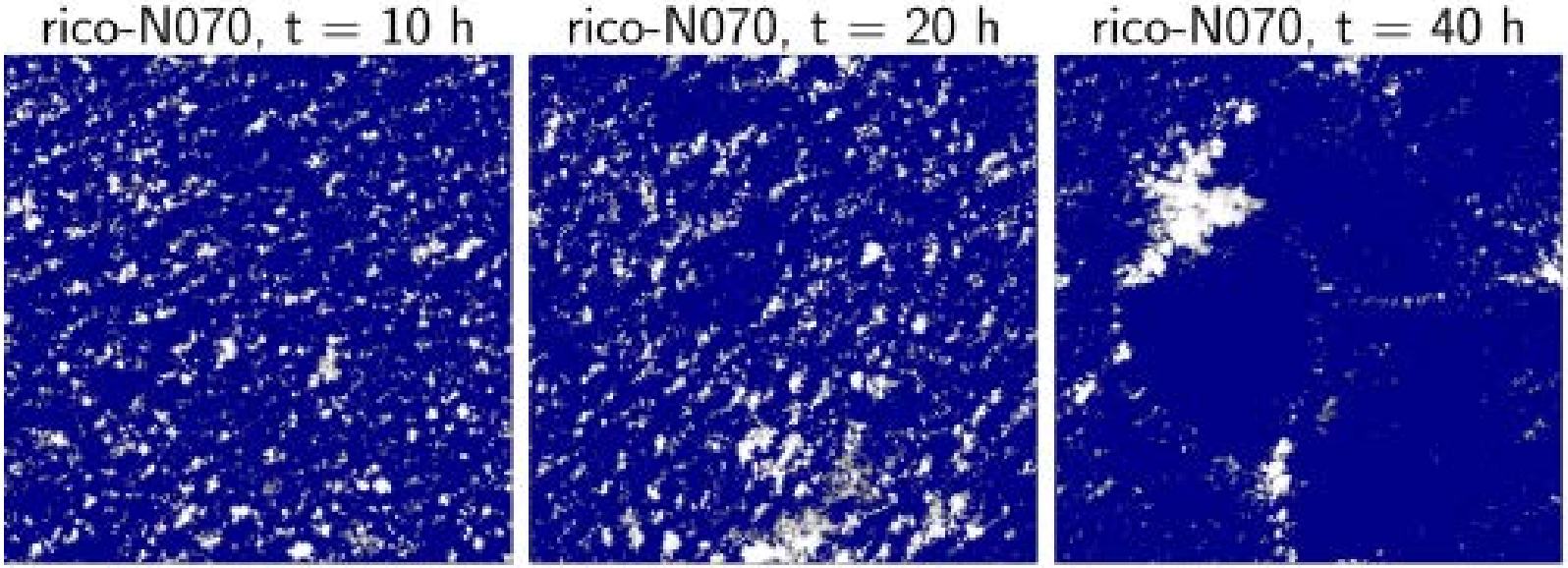


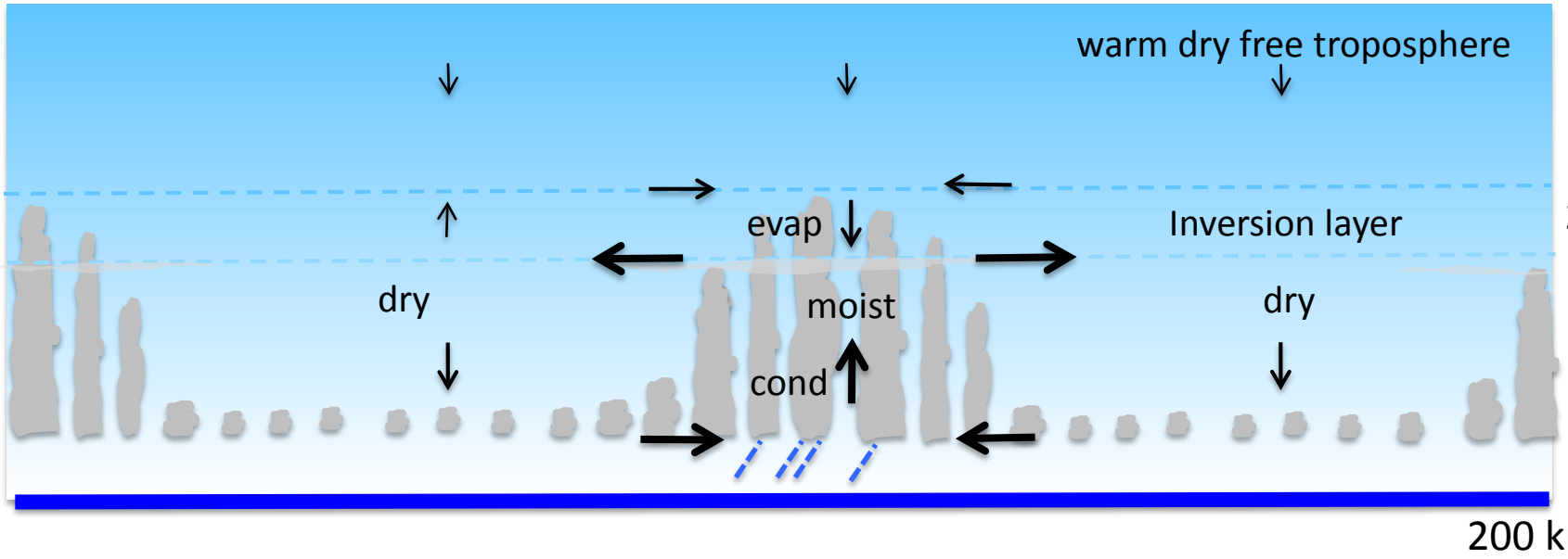
FIG. 2. Horizontal cross sections of cloud reflectivities calculated from the liquid water path (WET simulation): (left) $t = 4$ h, $z = 1600$ m; (right) $t = 12.5$ h, $z = 3100$ m. Cloud reflectivities have been estimated using the parameterization of Slingo (1989) assuming an equivalent radius of the drop size distribution of 6 μm and a solar zenith angle of 60°.



Seifert et al. 2015

Theoretical frameworks have been proposed

Moisture-convection feedback instability for shallow Cu aggregation



Bretherton and Blossey 2017 JAMES to be submitted

MBL mesoscale organization is ubiquitous, but why?

- How important are latent heating? cloud-radiation interaction? precipitation?
- Need a unified explanation that works across MCC types

  Closed cells: 'Inverse cascade' theory (de Roode et al 2004)

  Open cells: Humidity-convection feedback instability
- What sets 30:1 aspect ratio?
- Downscale w or q variance cascade from large scales relevant?

For what does MBL mesoscale organization matter?

- When does mesoscale organization affect horizontal mean:
  cloud?
  precipitation?
  aerosol?
- Mixed messages from LES on mesoscale domains
  Not too important for Sc and Cu under Sc
  (DeRoode et al. 2004;
  Important for deeper (>2.5 km) precipitating Cu
  (Seifert et al. 2015; Bretherton et al. 2005)

Cloud microphysics and MCC

- Why doesn't most precipitating closed-cell Sc transition into POCs?
- Clusters of precipitating Cu may promote ultra-clean veil clouds
- Interaction of mixed-phase with meso-aggregation in CAOs?
- Does mesoscale organization affect aerosol susceptibility of cloud? of precip?
- Are cold pools the most important organizing mechanism?