**Unprecedented evidence for deep convection hydrating the tropical stratosphere**

Thierry Corti, Beiping Luo, Thomas Peter (ETH Zürich, Switzerland) and the Geophysica team

**Abstract:** We report on in situ and remote sensing measurements of ice particles in the tropical stratosphere found during the Geophysica campaigns TROCCINOX and SCOUT-O3. We show that the deep convective systems penetrated the stratosphere and deposited ice particles at altitudes reaching 420 K potential temperature. These convective events had a hydrating effect on the lower tropical stratosphere due to evaporation of the ice particles. In contrast, there were no signs of convectively induced dehydration in the stratosphere.

---

### In situ formation?

![Figure 3. Growth and sedimentation assuming 130% relative humidity over ice.](image)

- Supersaturation required ➔ but subsaturation observed
- Some particles would have had nucleated at around 23 km and grown during 1 h to reach the observed size of 100 µm ➔ unrealistic.

### Contrail sampling?

![Figure 4. Contrail tracking using measured wind (UCSE) and wind from ECMWF operational data, taking the contrail's spreading into account.](image)

- In some cases, contrail sampling was impossible because some convective systems were overflown only once.
- Some ice particle observations (~3%) might have originated from contrail sampling. These observations were excluded from Figure 1.

### Convective overshoots!

![Figure 5. Air parcel model for an overshooting event.](image)

- Supported by downward looking lidar MAL (Figure 2c).
- Air parcel model shows that such overshoots are possible (Figure 5).
- The only plausible explanation.

### Impact

![Figure 6. Modelling the sedimentation and evaporation of observed ice particles.](image)

- Typical: r < 15 µm ➔ evaporation in the stratosphere
- r ≥ 20 µm ➔ sedimentation back

### Attempt of an Upscaling (tropics, 20°N–20°S)

Using global statistics of convective overshooting (Li and Zipser, 2005)

**Assumption 1:**

- H₂O transport duration of overshoot
  - Hector: 10⁵ kg H₂O/hr
  - TRMM: 12 events on average at any time
  - 12 × 24 × 10⁵ = 3 × 10¹⁵ kg H₂O per day
  - Compared to 10¹⁵ kg H₂O per day from large scale upwelling
  - 3% contribution from convection

**Assumption 2:**

- H₂O transport duration of overshoot
  - Hector: 10⁵ kg H₂O/hr (40 km³)
  - TRMM: 12 events on average at any time with 722 km² mean area
  - 12 × 124 × 10³ × 5 × 10⁹ kg H₂O per day
  - Compared to 10¹⁵ kg H₂O per day from large scale upwelling
  - 5% contribution from convection

This remains inconclusive.