Regional Air Chemistry

Vertical Transport of Trace Gases by Convective Storms

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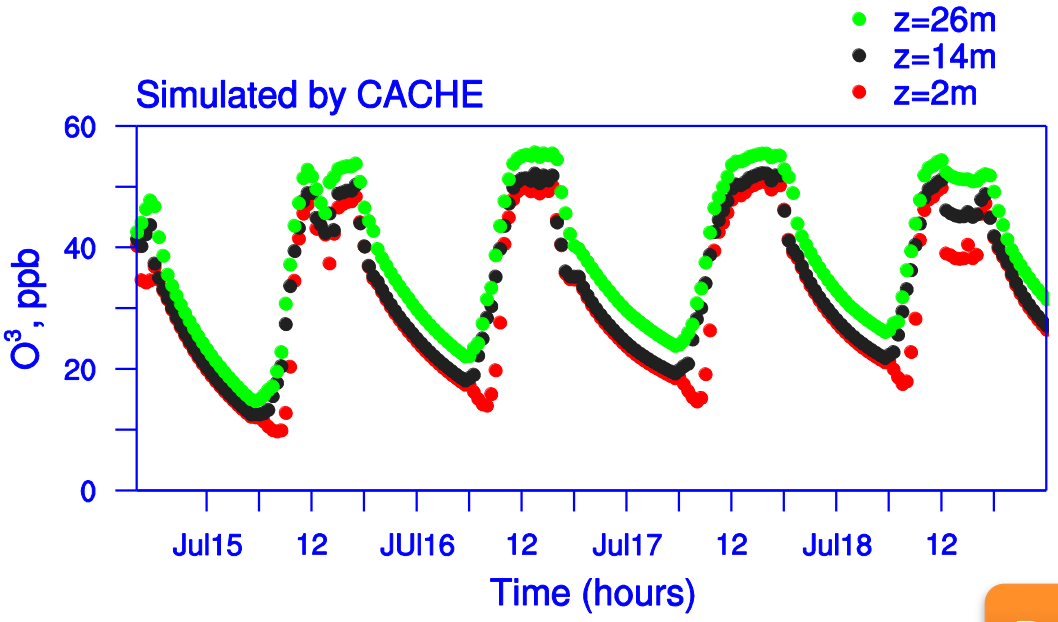
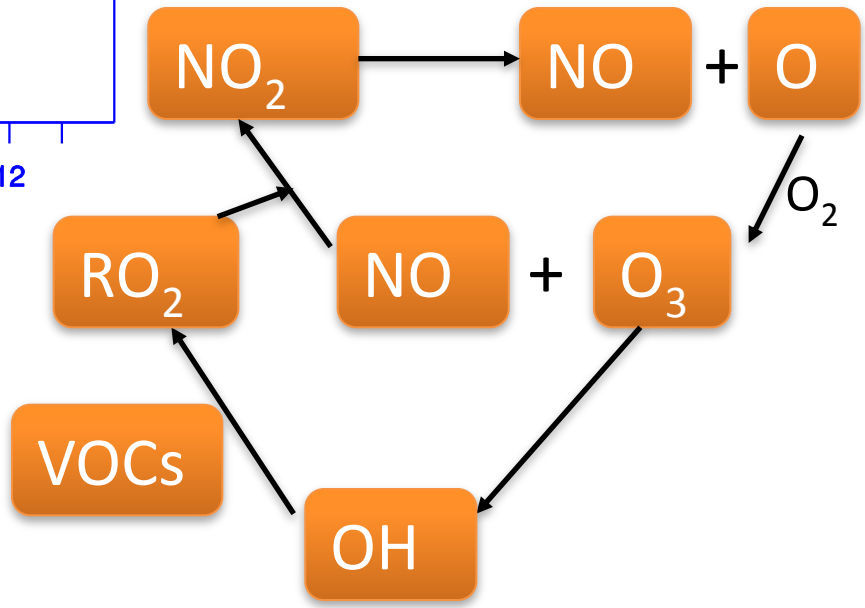
Friday “Frank Talk” on Mar. 5, 2010

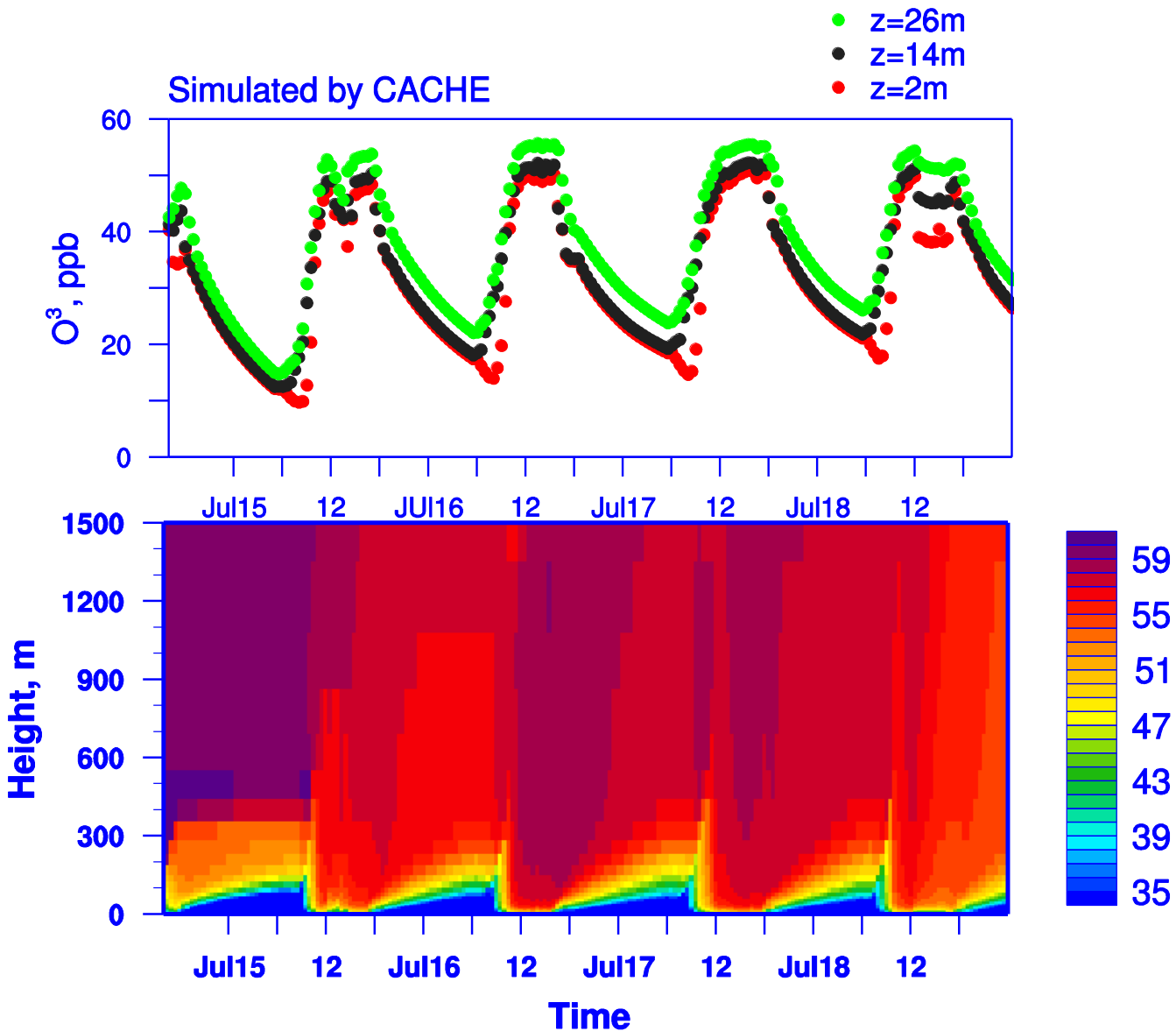
Surface O_3 Mixing Ratio



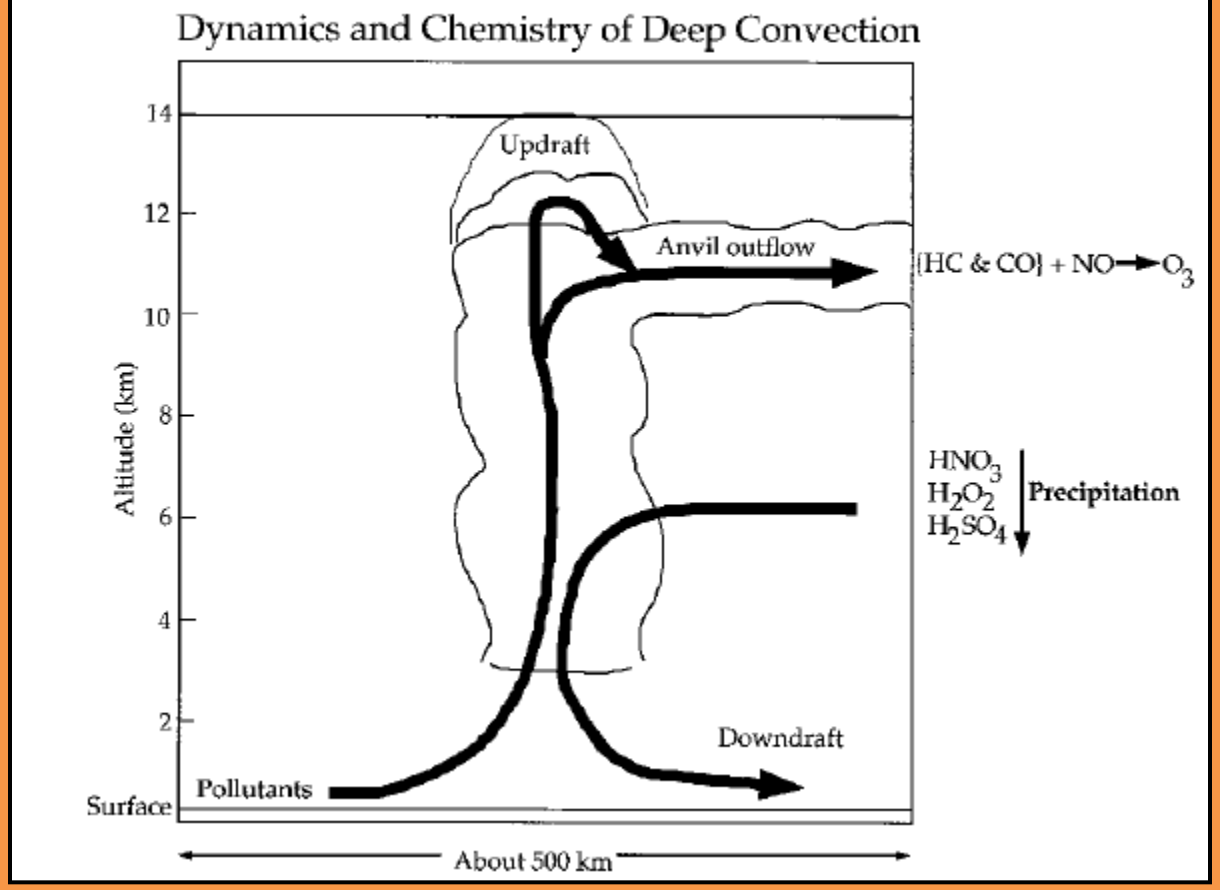


CACHE model: one-dimensional Canopy Atmospheric Chemistry Emission model.

Local Production or Vertical Transport?



Trace gas vertical transport associated with deep convection

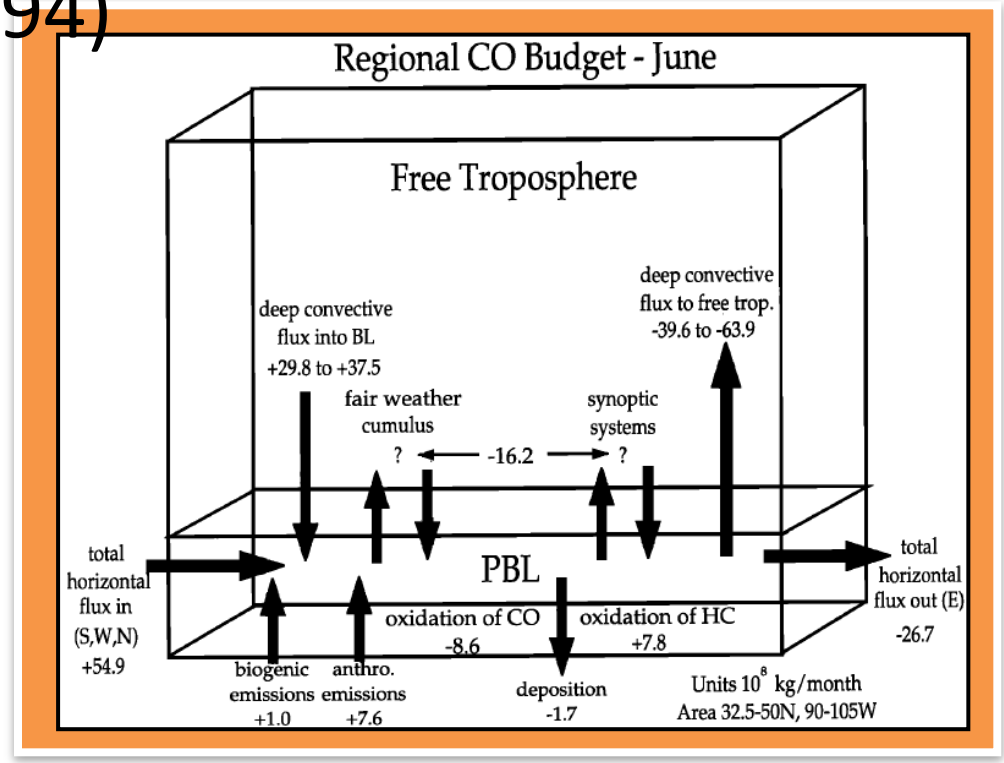


Thompson et al. 1997

Deep convection vertical transport: a quick and effective way

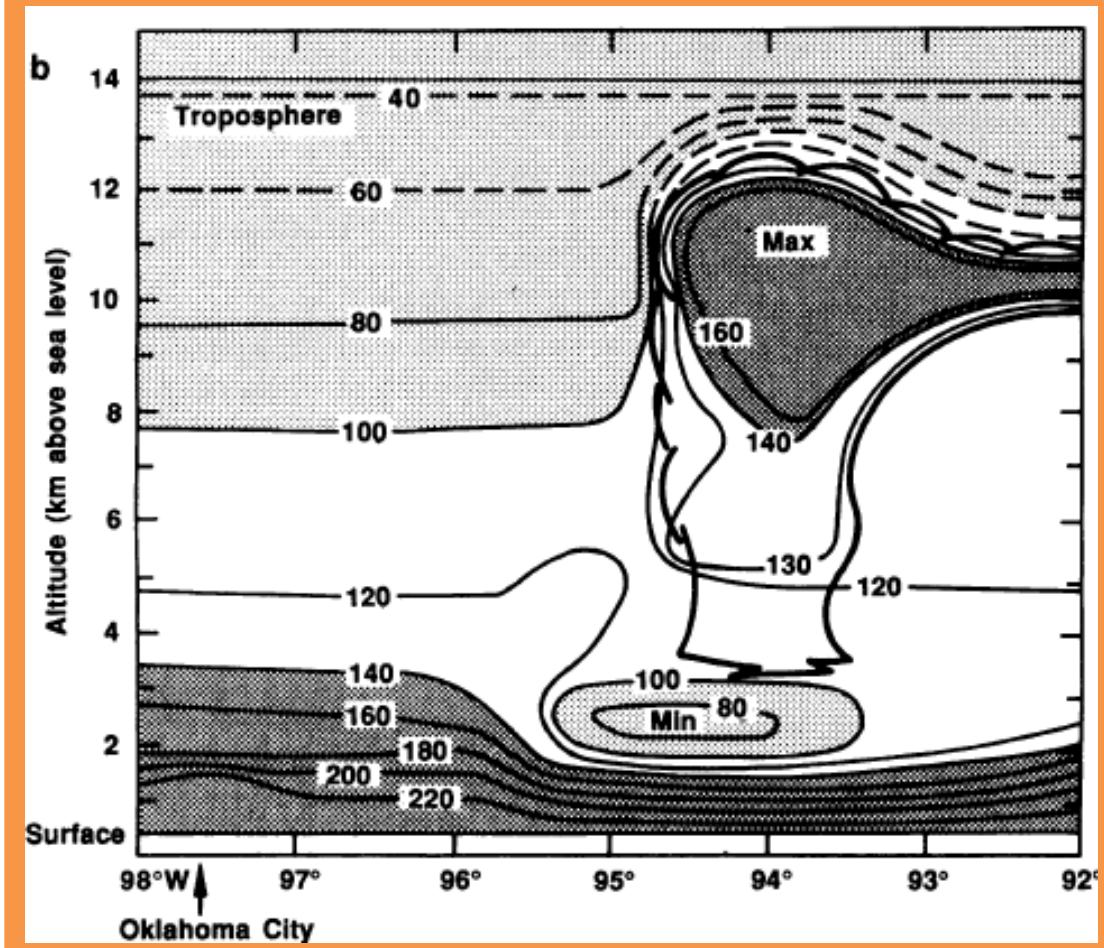
- Deep convections occur in 30 min or less.
- Half the CO entering the PBL over central U.S. is transported upward by deep convection (Thompson et al. 1994)

Thompson et al. (1994)
Central U.S. acts like a **chimney**



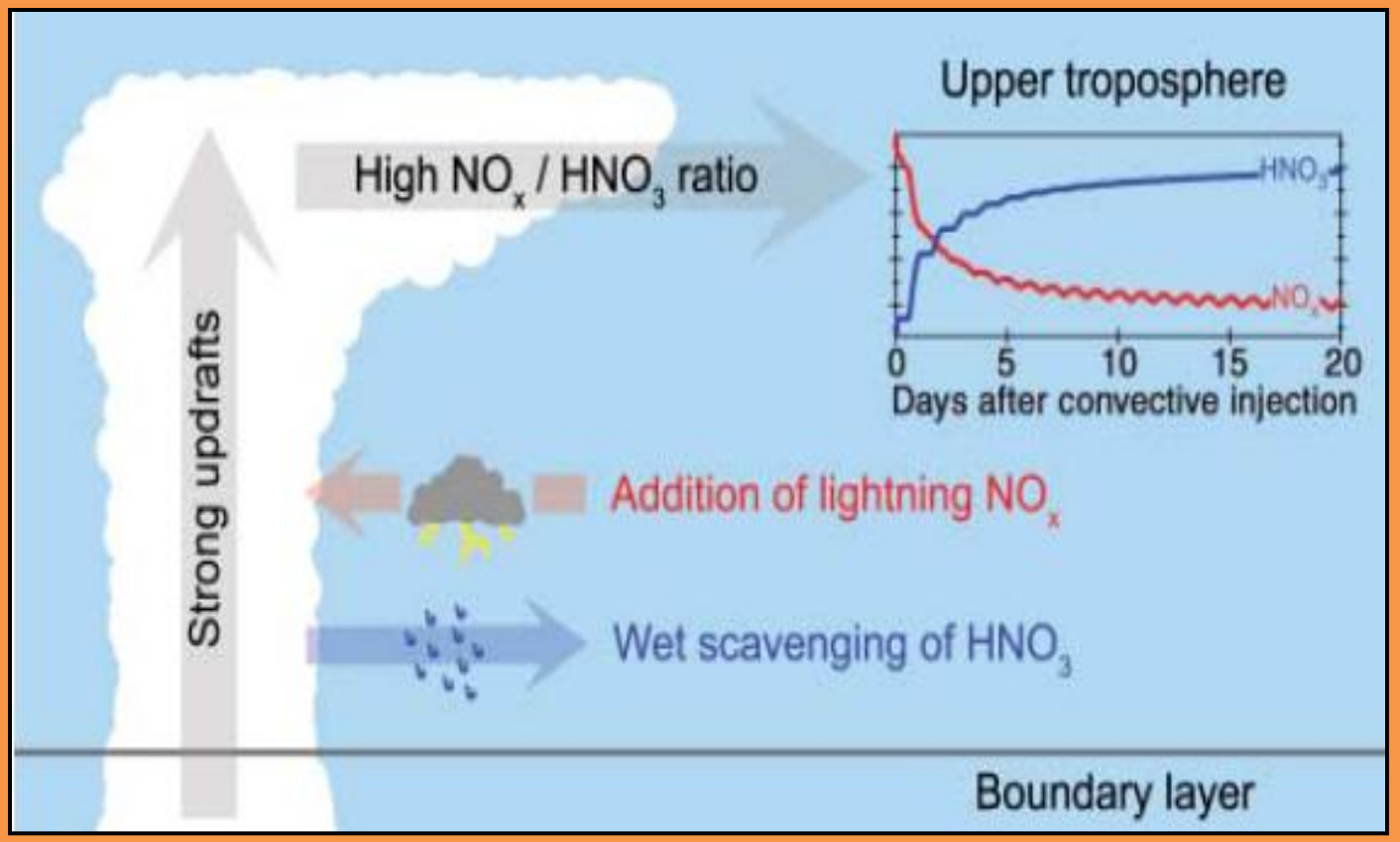
Upward Transport of CO

[co] in ppb



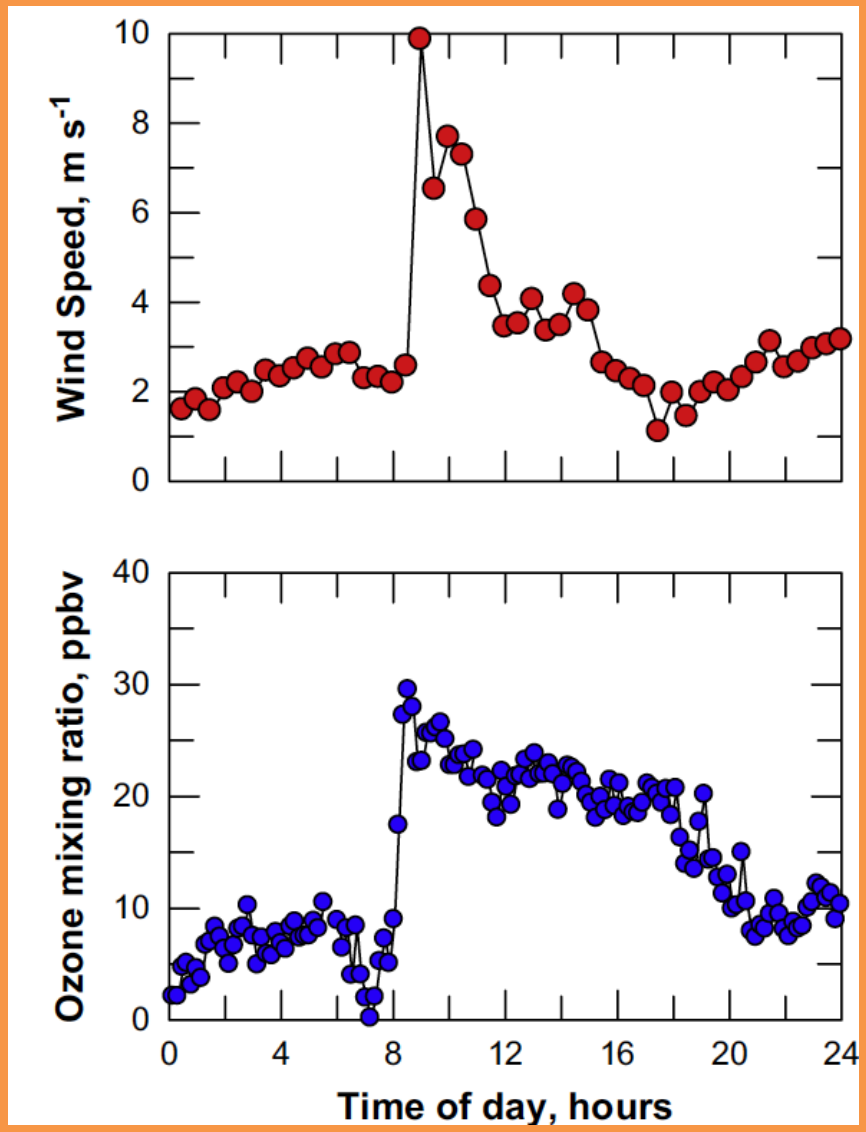
Dickerson et al. (1987)

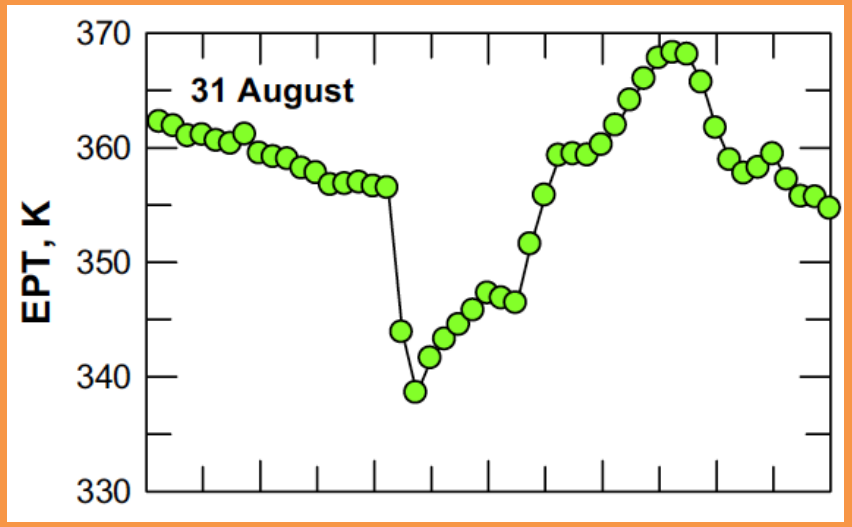
Upward Transport of NOx



Bertram et al. (2007)

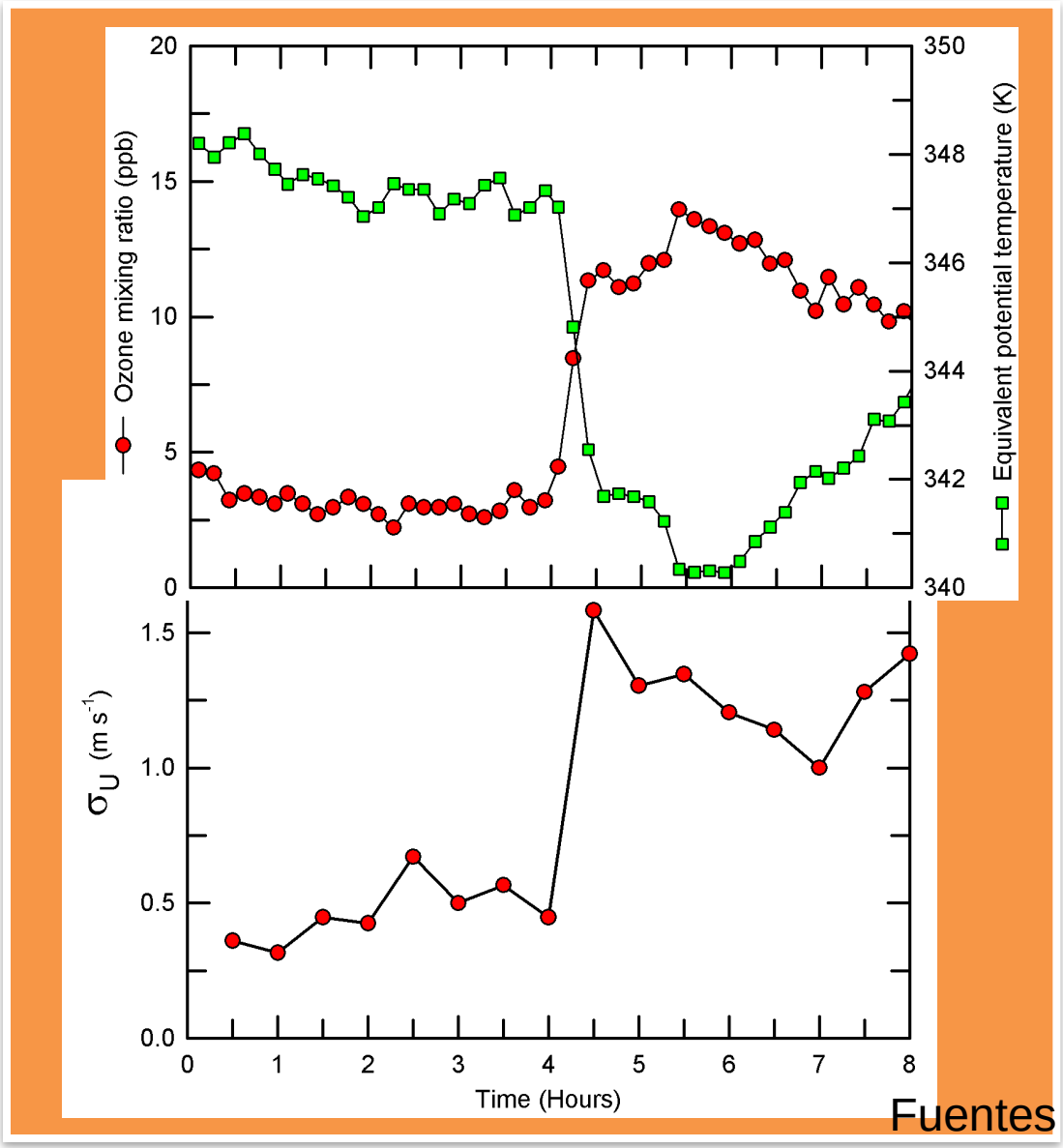
Surface Ozone Changes Following Convective Storms 1





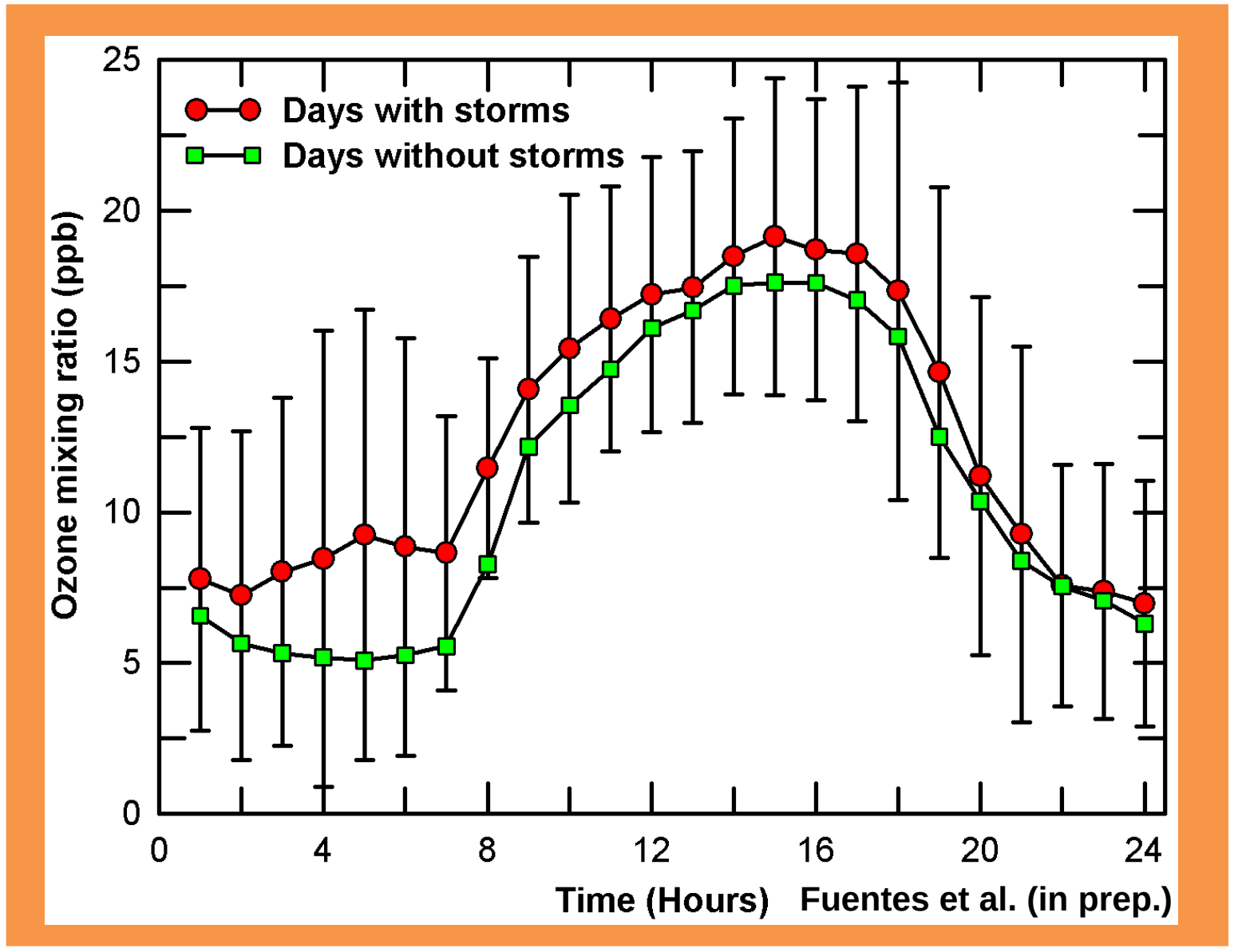
Grant, Fuentes et al. (2008)

Surface Ozone Changes Following Convective Storms 2

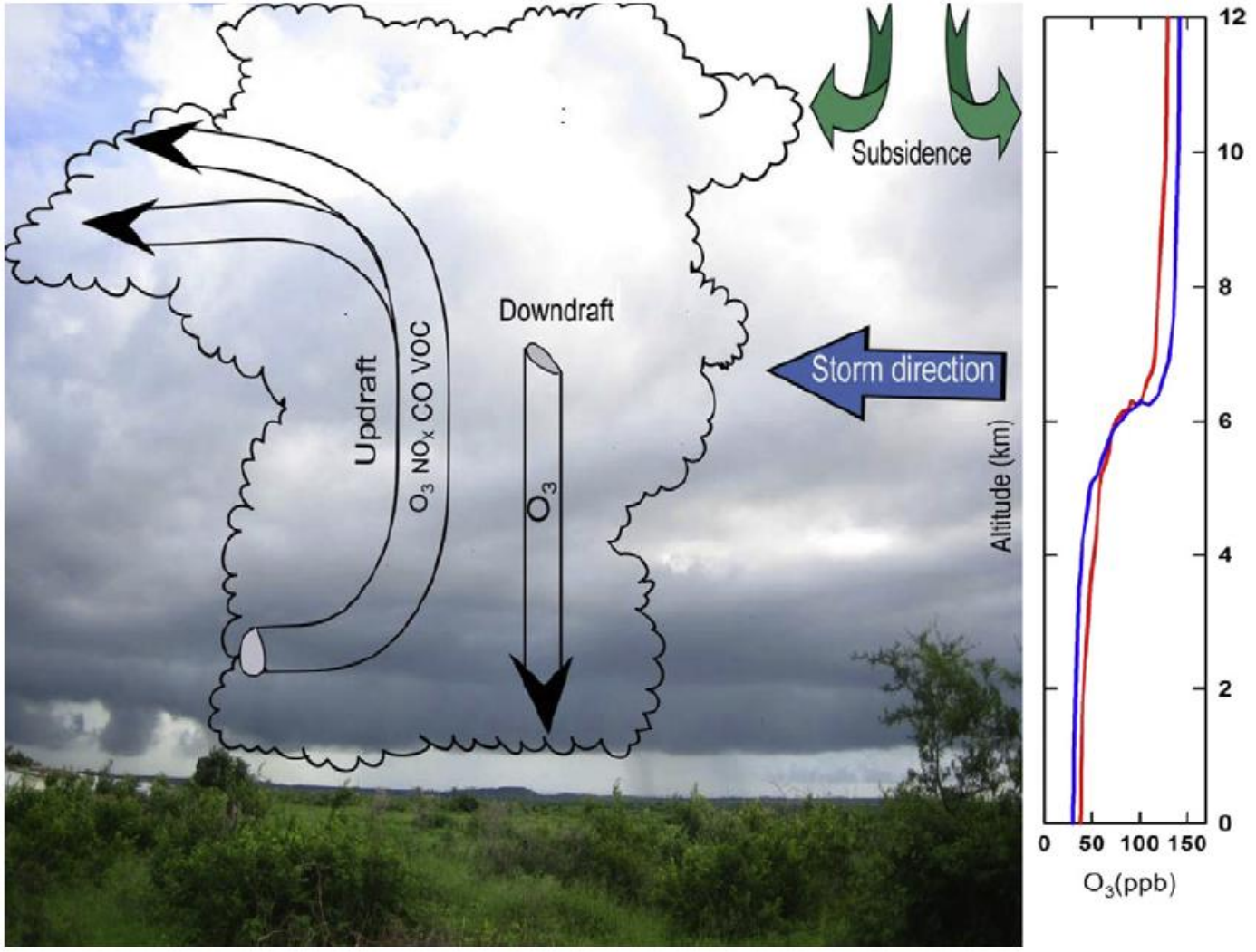


Fuentes et al. (in prep.)

Surface Ozone Changes Following Convective Storms 3



Conceptual Model of O_3 Transport



Grant, Fuentes et al.(2008)

Importance of Downward Transport

- O_3 profile will change
  - Radiative forcing
  - Dry deposition
- HO ("detergent" of the troposphere) will increase in lower tropical troposphere (downward transported O_3+enriched H_2O near surface)
  - VOC+HO
  - CO+HO
  - CH_4+HO

Objectives and Approach

Objectives

- Estimate the downward transport of O_3 by convective storms, and verify current conceptual models.
- Quantify the subsequent effect on air chemistry in lower tropical troposphere.
  - Estimate OH production
  - VOC, CH_4, CO…+OH

Approach

- Cloud Resolving WRF/Chem Simulation

Cloud Resolving Modeling: Step 1

Model: WRF

Episode: Aug. 31, 2006 in west Senegal

Resolution

- Resolutions of 3 nested domains: 27km, 9km, 3km
- Vertical layers: 60 layers up to 10hPa

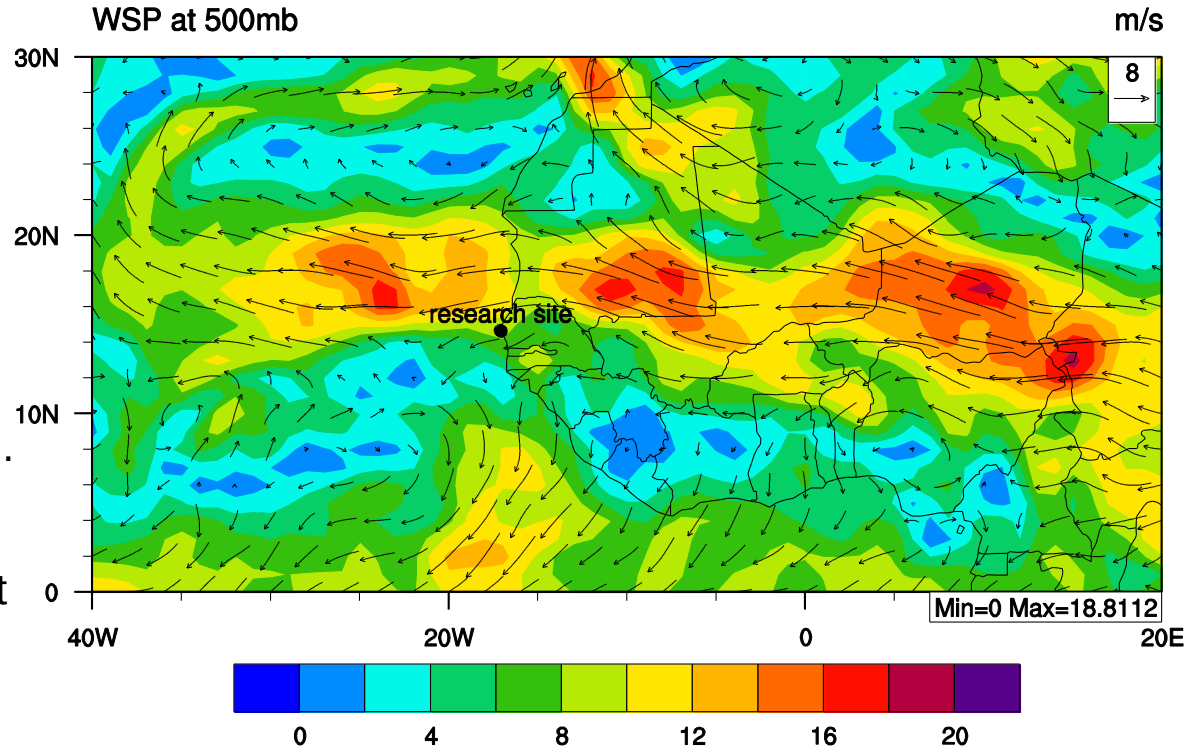
Configuration

- Turn off cumulus scheme
- …

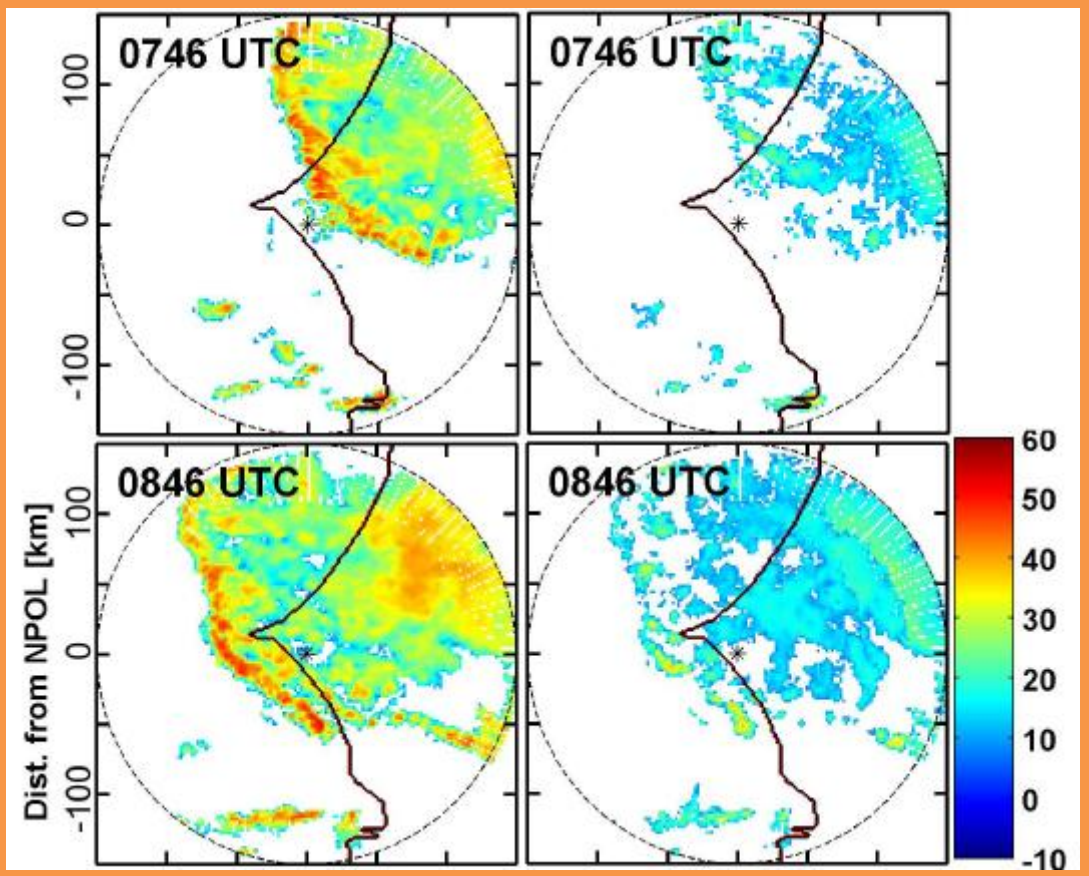
Field observations

Ozone data [Grant, Fuentes et al. (2008)]

Radar data [DeLonge, Fuentes et al. (2010)]



Radar Reflectivity for the Seleted Episode



Cross sections at 3 km (left) and 6 km (right)

DeLonge, Fuentes et al.(2010)

Cloud Resolving Modelling: Step 2

Model: WRF/Chem: online model.

Advantages:

- Chemistry is simulated simultaneously with dynamics. The update frequency of input of metrological variables to chemistry simulation could be as short as minutes.
- The chemical-dynamical feedbacks can be simulated.
- Since the same coordinate is used for both chemistry and dynamics simulation. No interpolation is needed.