Meteoric metal chemistry in WACCM

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NESL

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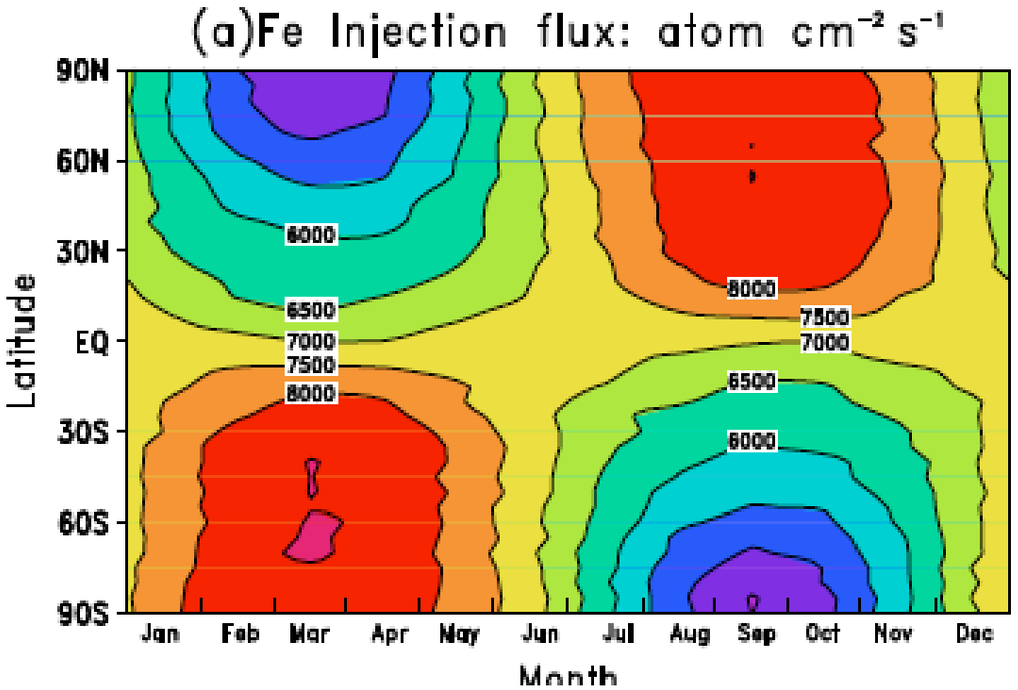
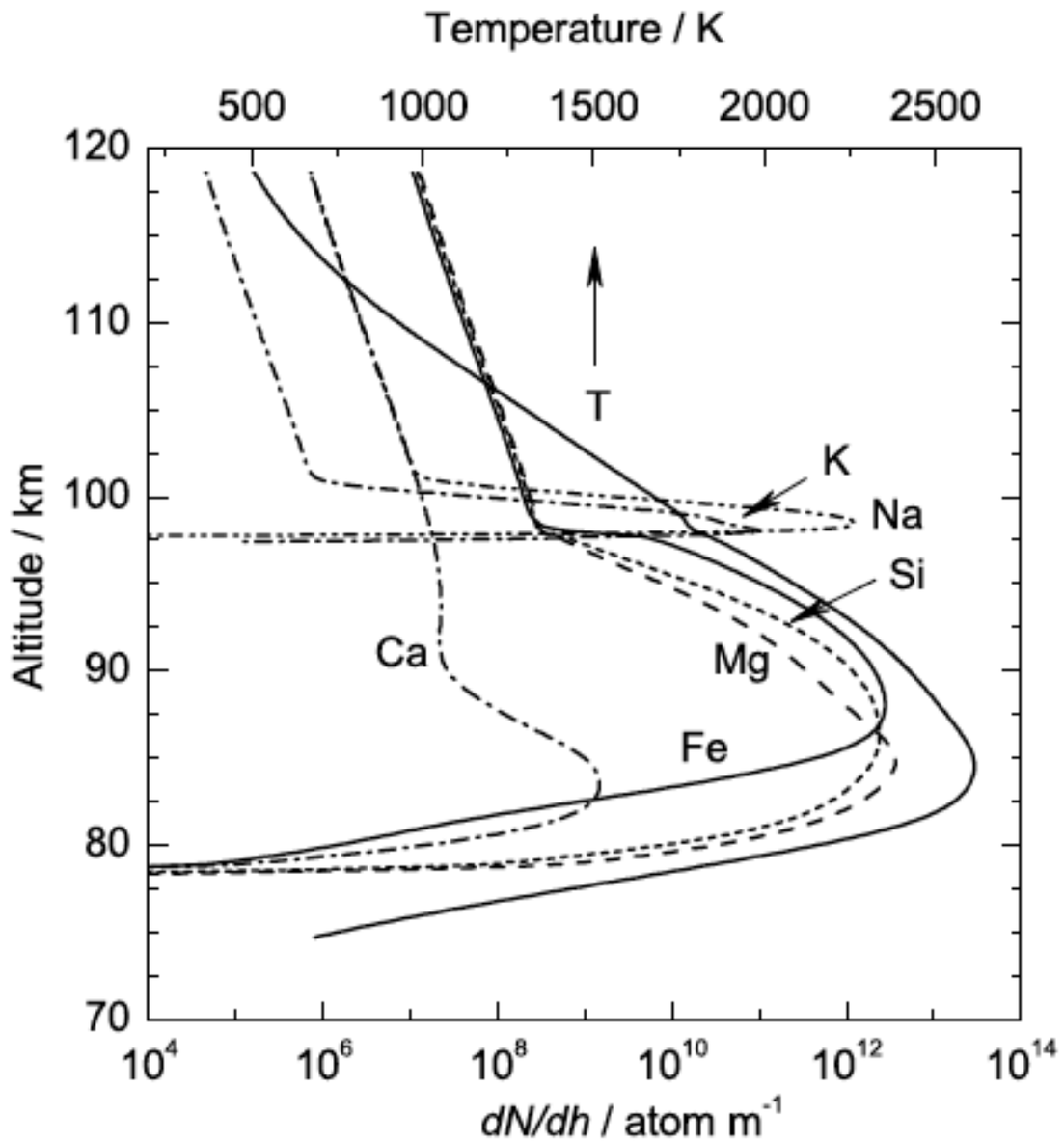
Outline

- Model components
  - Meteor input function
  - Ablation model
  - Metal chemistry scheme
- Sodium and iron as dynamical tracers:
  - Mean meridional circulation
  - Stratospheric sudden warming
  - Atmospheric tides
  - Eddy diffusion

Meteoroid Input Function (MIF)



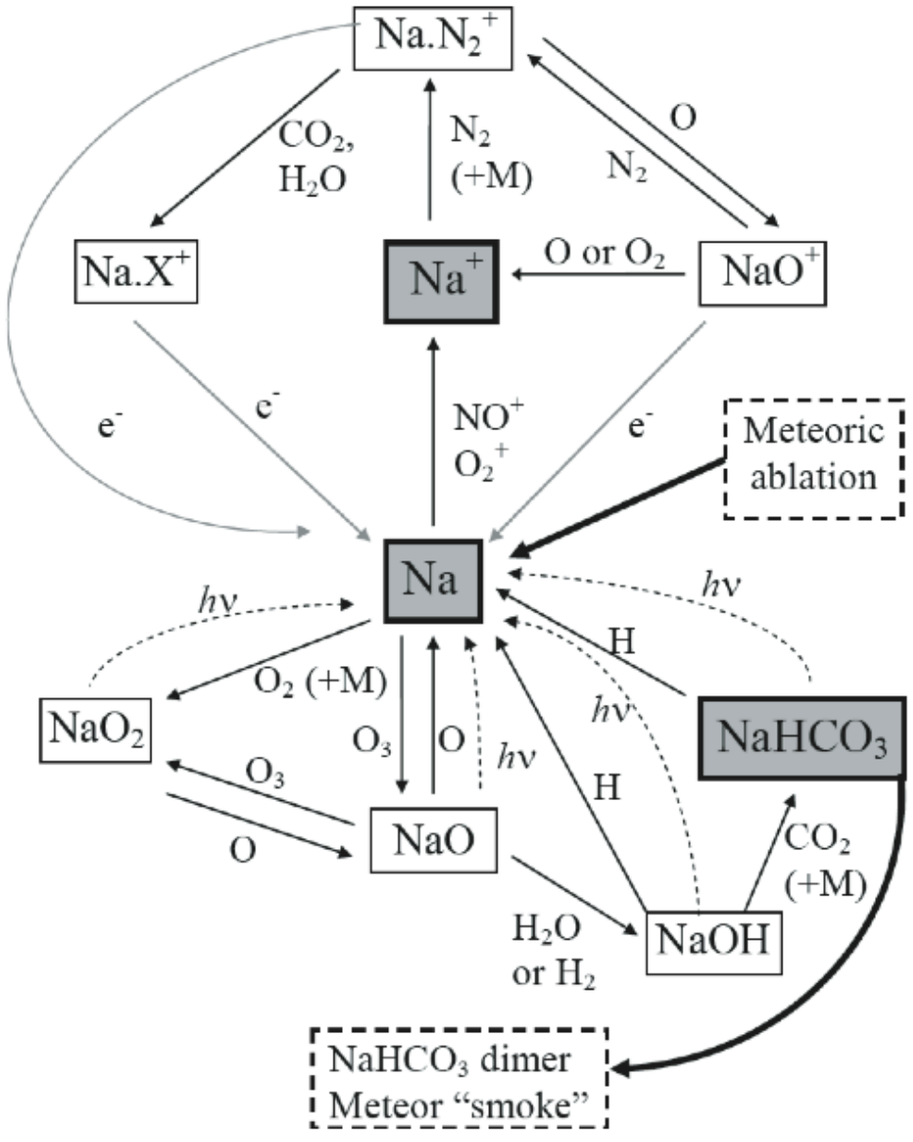
An astronomical model of meteoroid fluxes is combined with a chemical ablation model (CABMOD, Vondrak et al. [2008]) to provide a climatology of metal deposition.

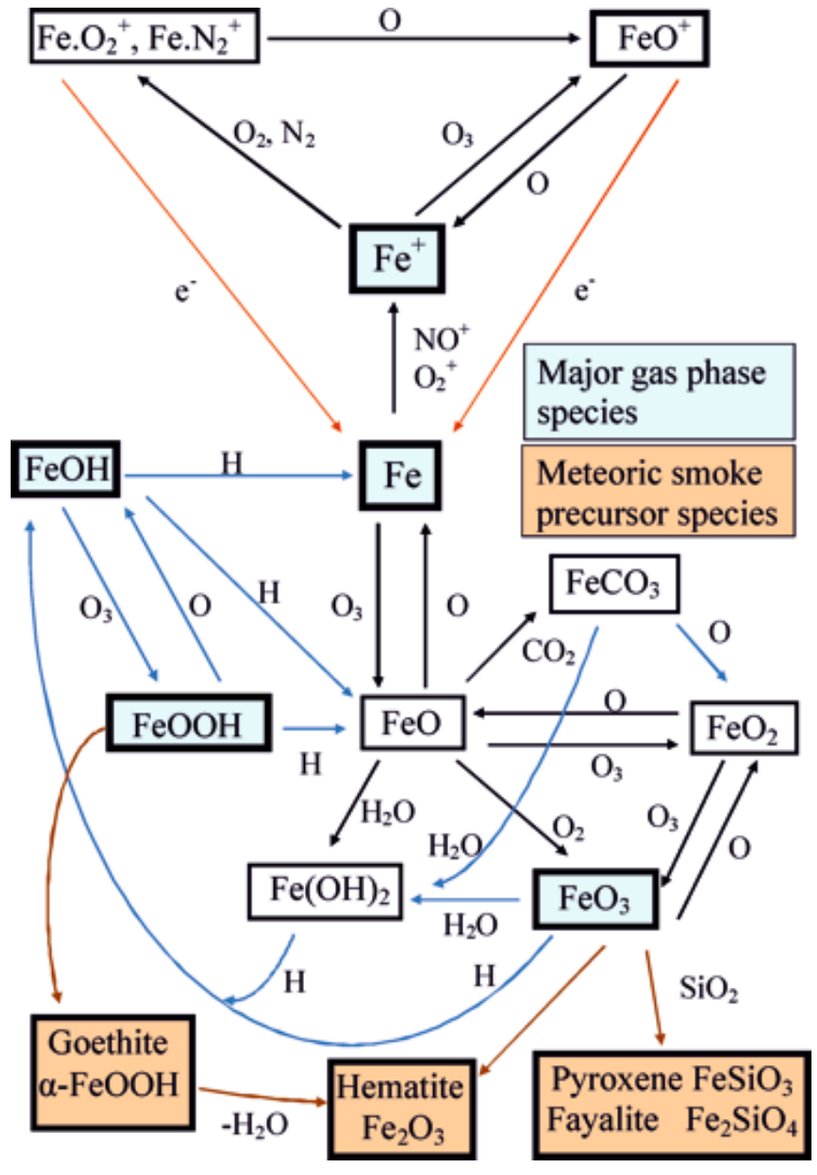


Vondrak et al. [2008]

Na and Fe chemistry schemes

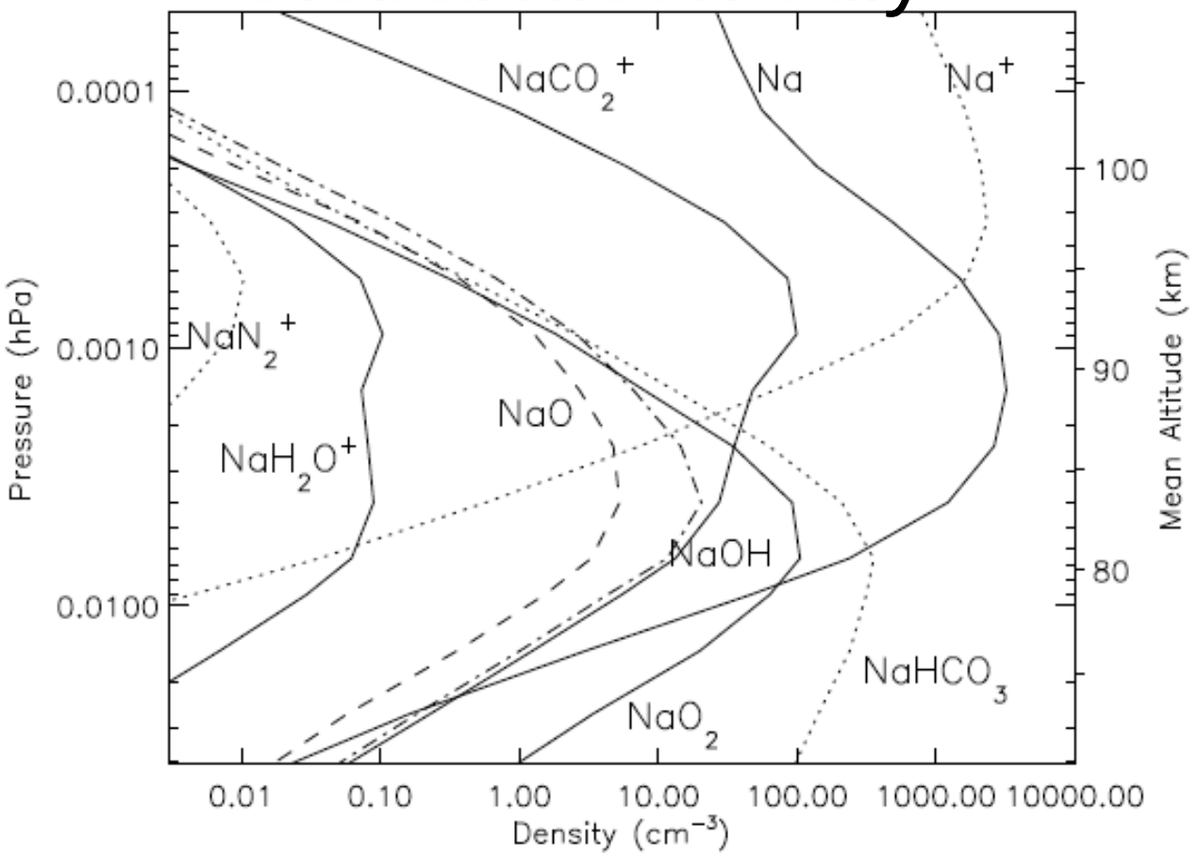
Metal chemistry is fully interactive with standard 66 species neutral and ion chemistry scheme.



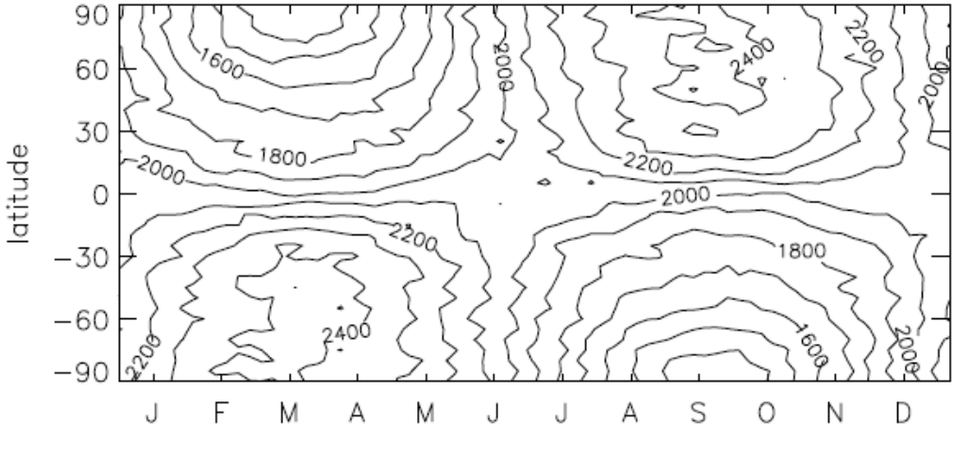


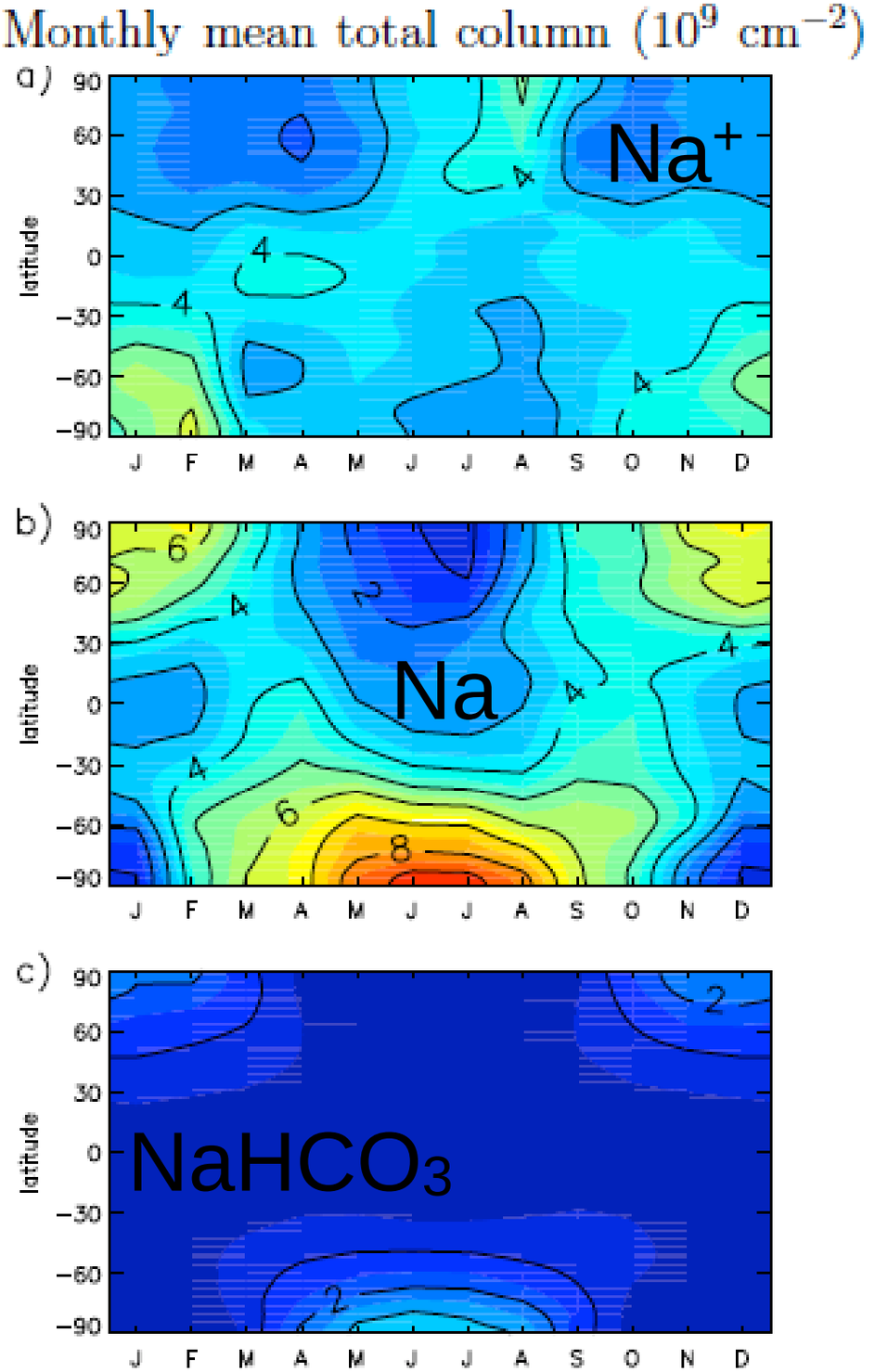
WACCM simulated distribution of Na species

Global mean July



Na+ most closely follows the MIF seasonality

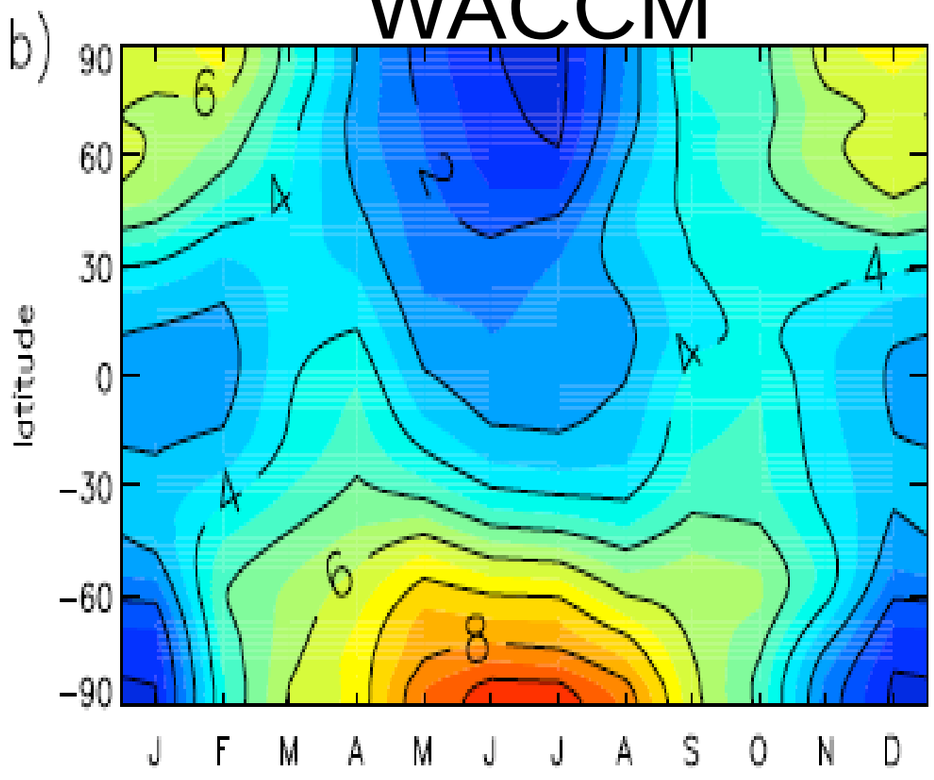


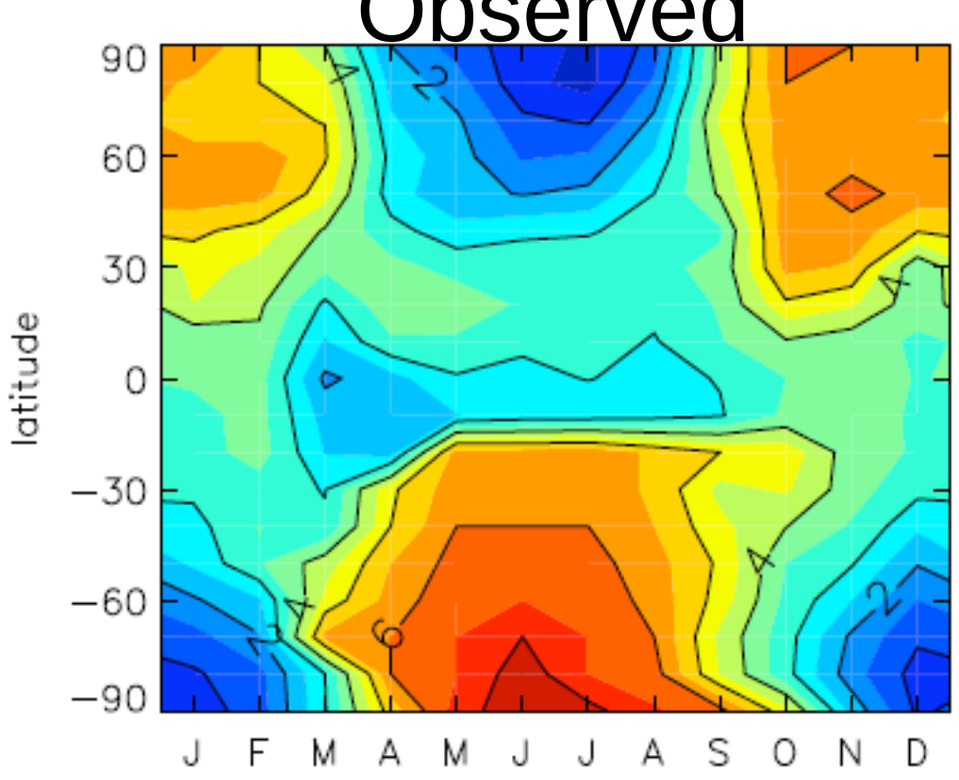


Strong annual cycles in Na total column

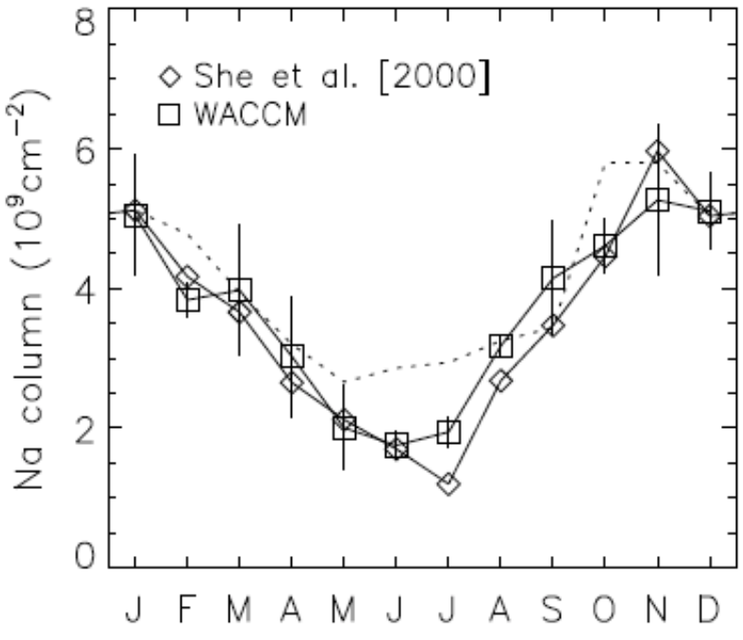
WACCM

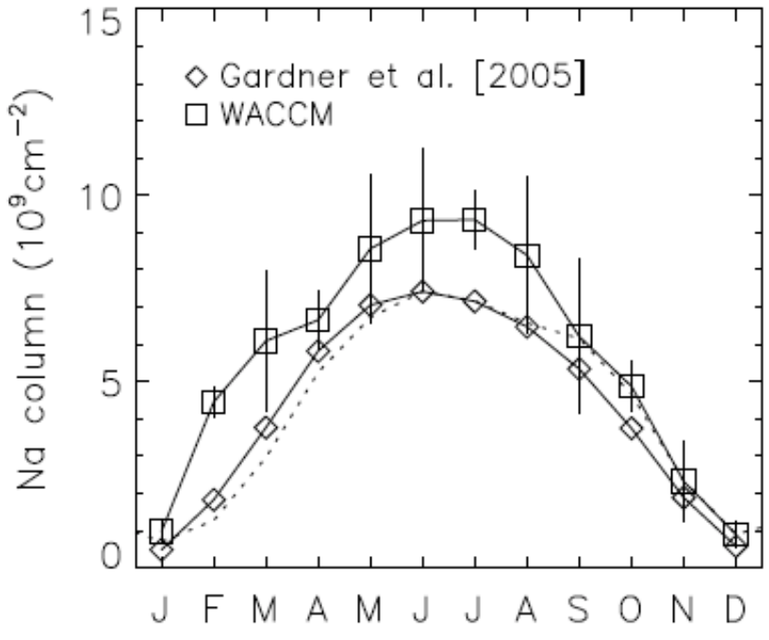
Observed





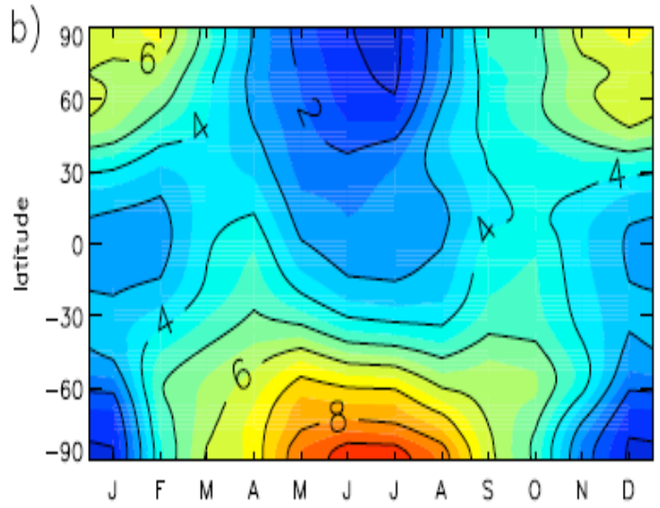
Fort Collins

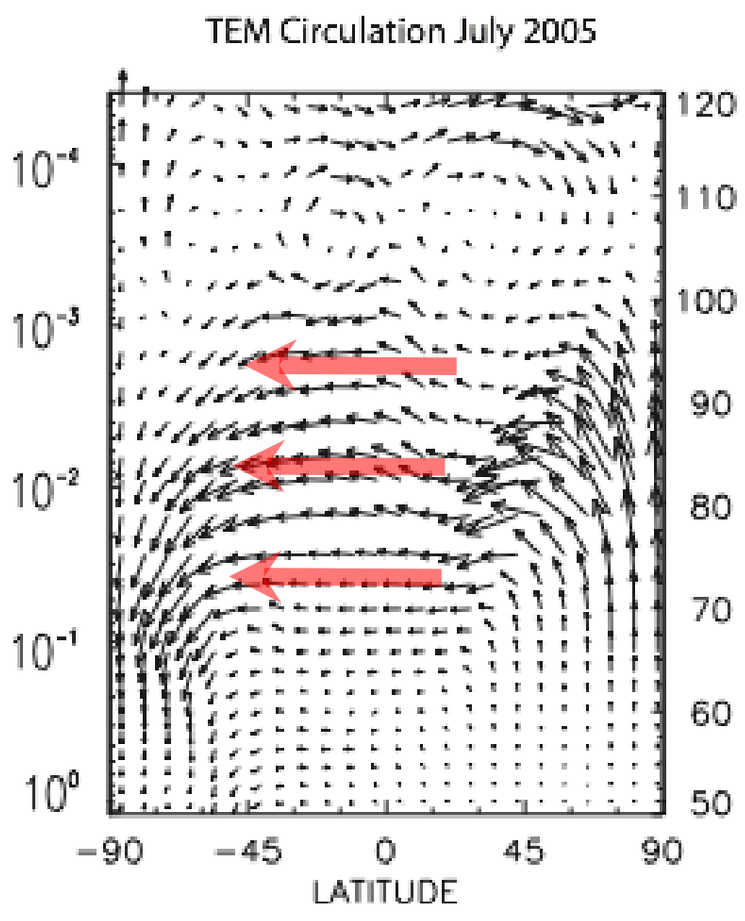




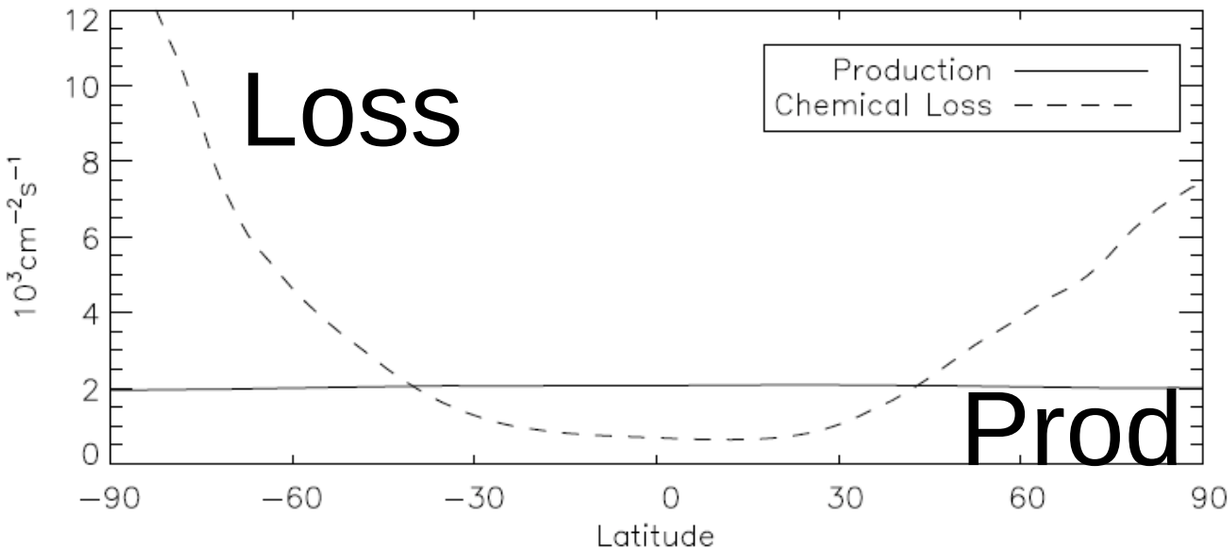
South Pole

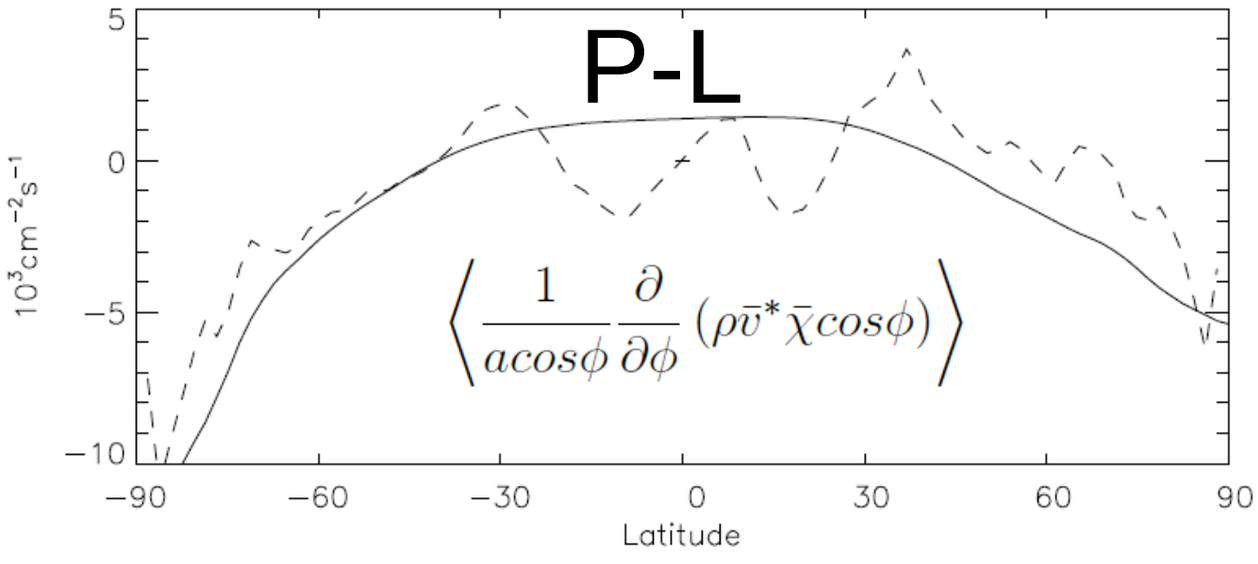
P-L balanced by meridional advection



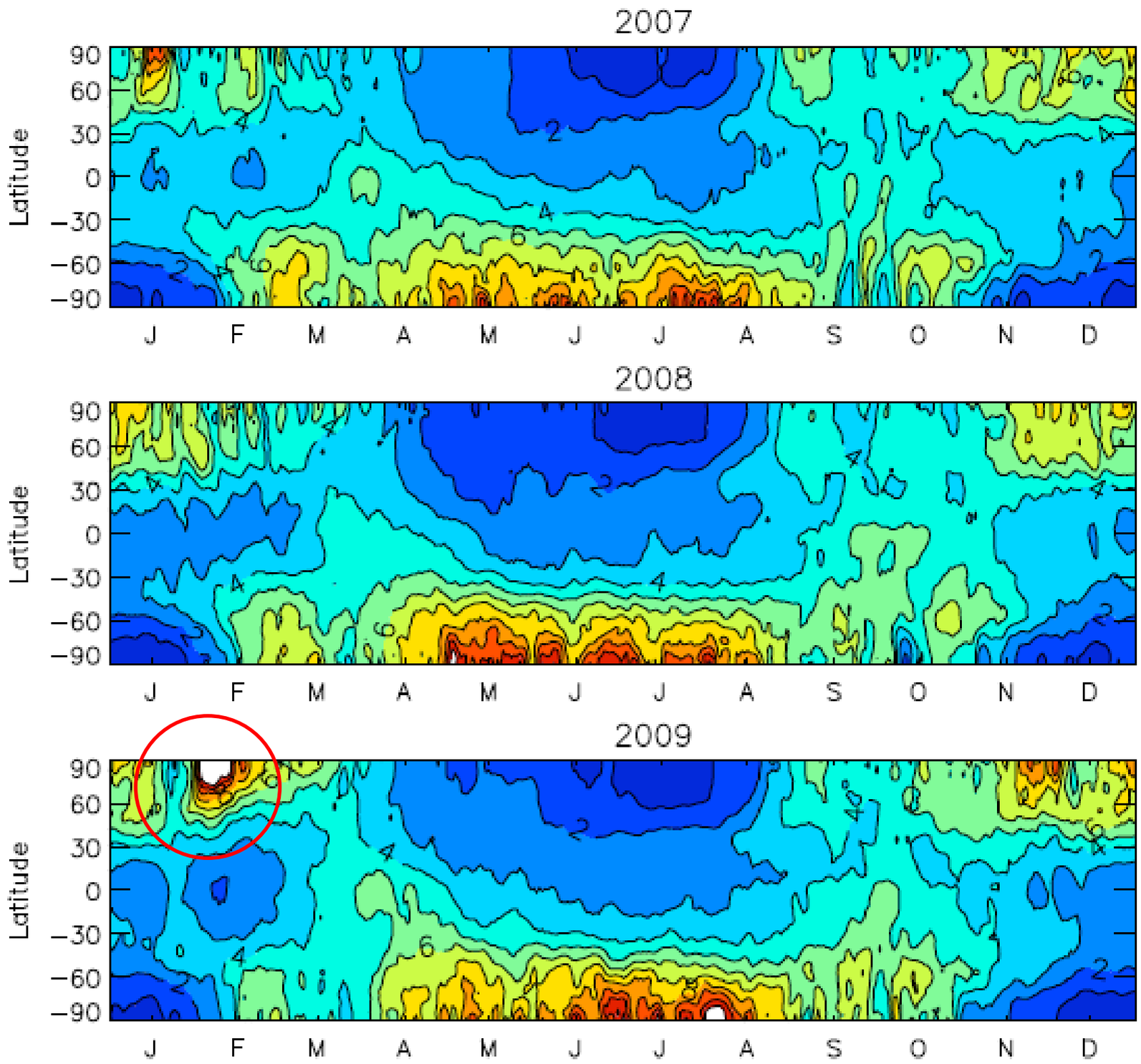


Annual mean vertical integral

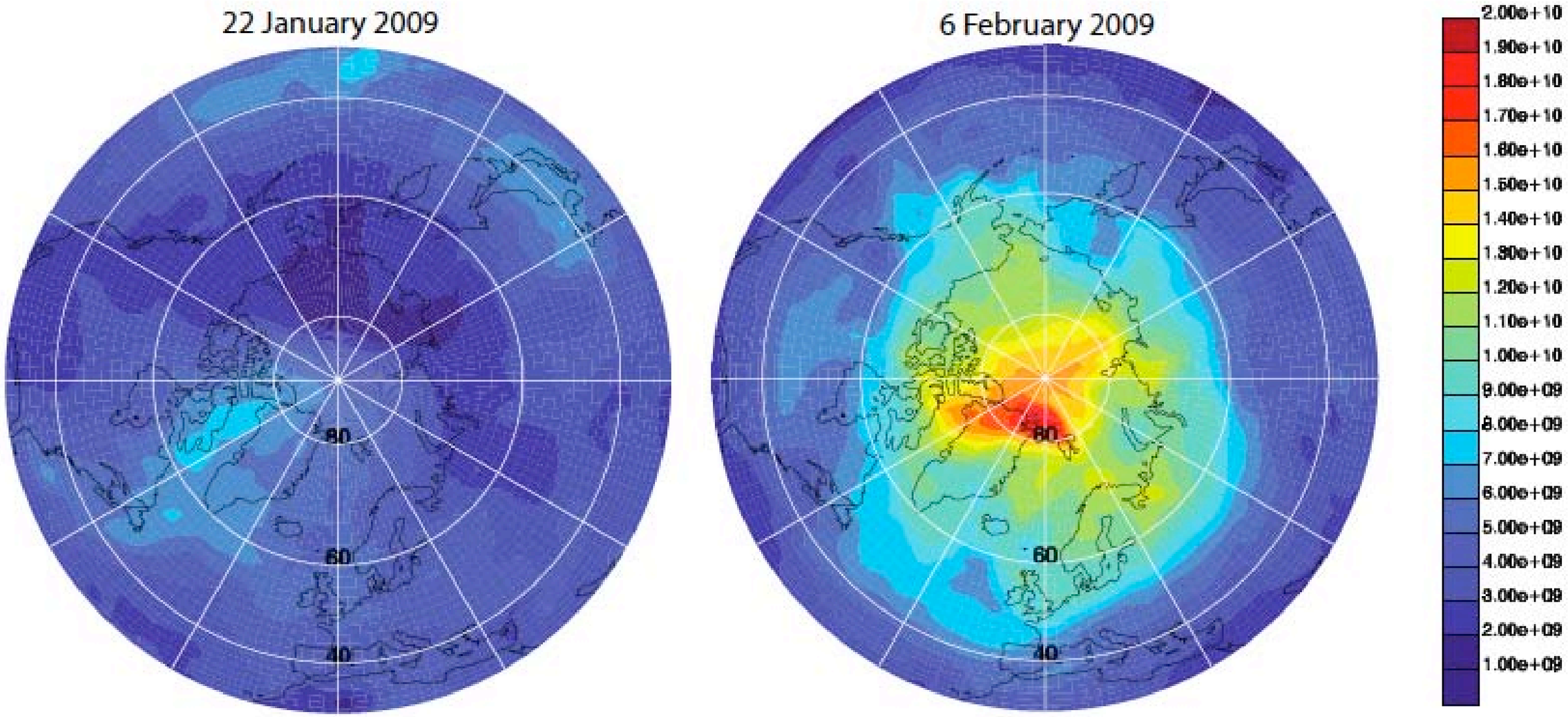




WACCM-Na driven by MERRA reanalysis

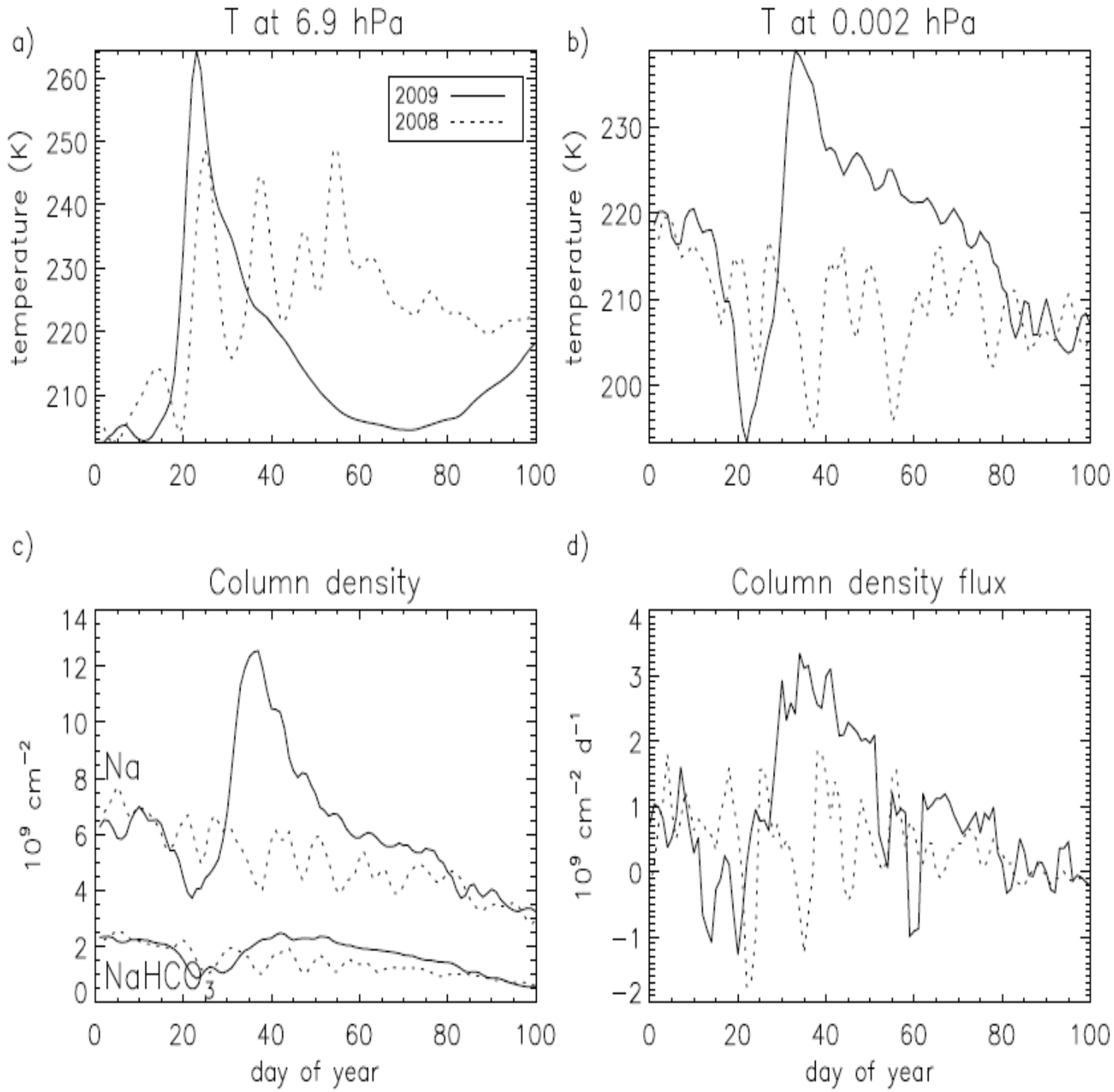


24 January 2009 major stratospheric sudden warming

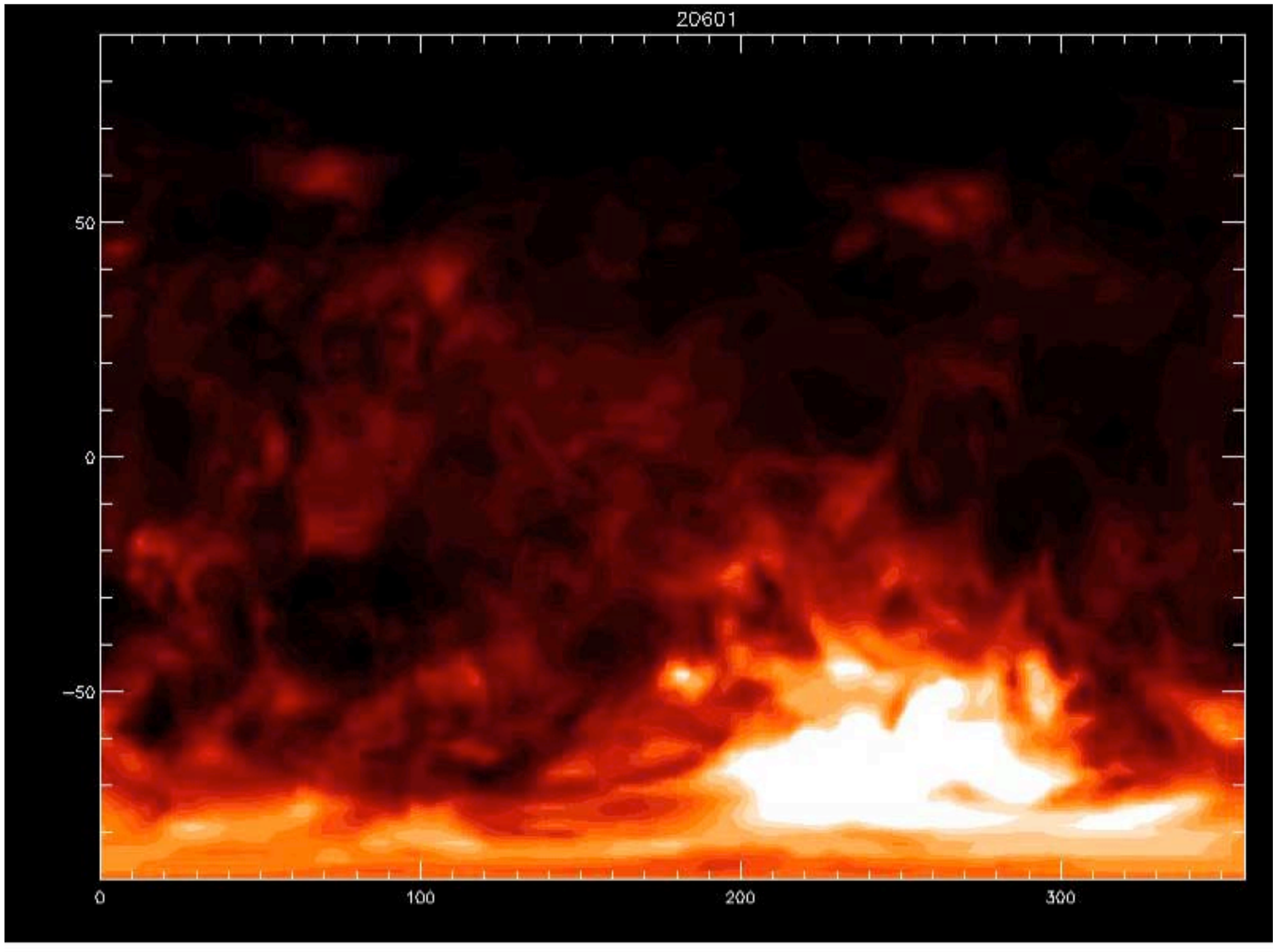


Polar cap averages of T, Na column, Na flux

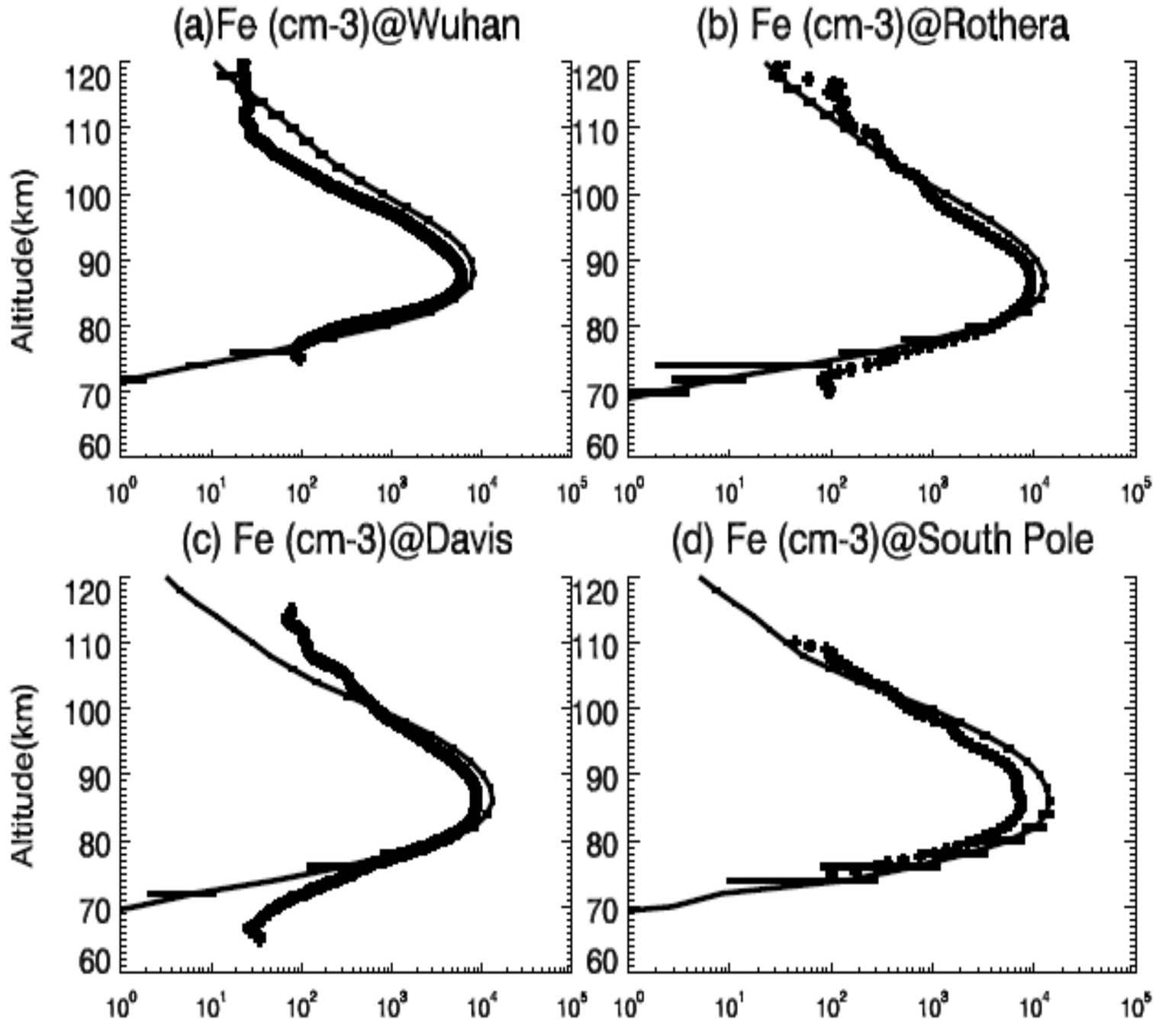
- Strat. warming leads to mesospheric cooling
- Mesosphere then warms due to convergence and downwelling over pole
- Na over cap increase by 3x
- Not a repartitioning - all Na species increase
- Increase from transport of Na species from lower latitudes



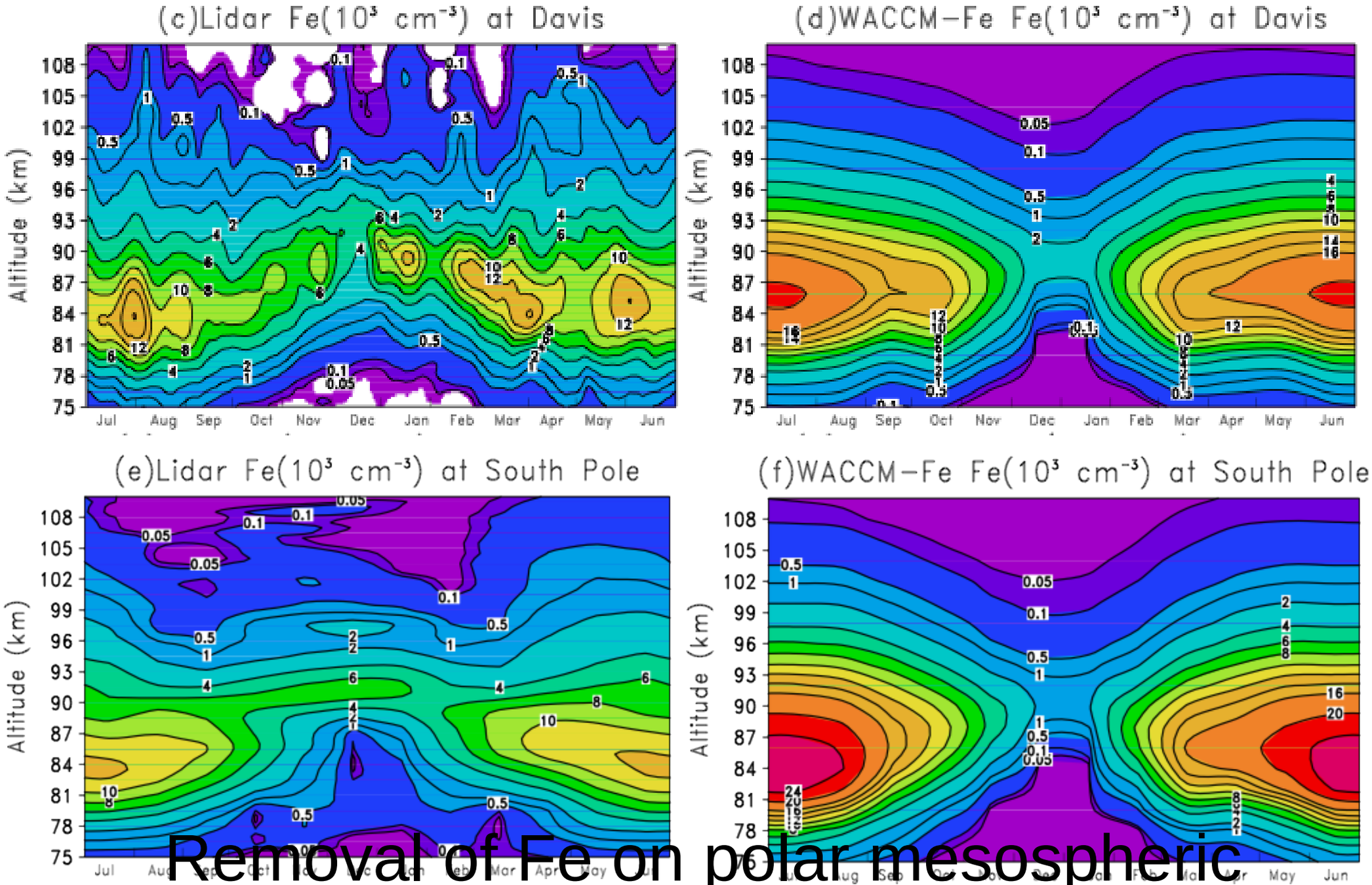
Daily ‘snapshots’ of sodium ~90km / UT00



Fe vertical density profiles compared to LIDAR

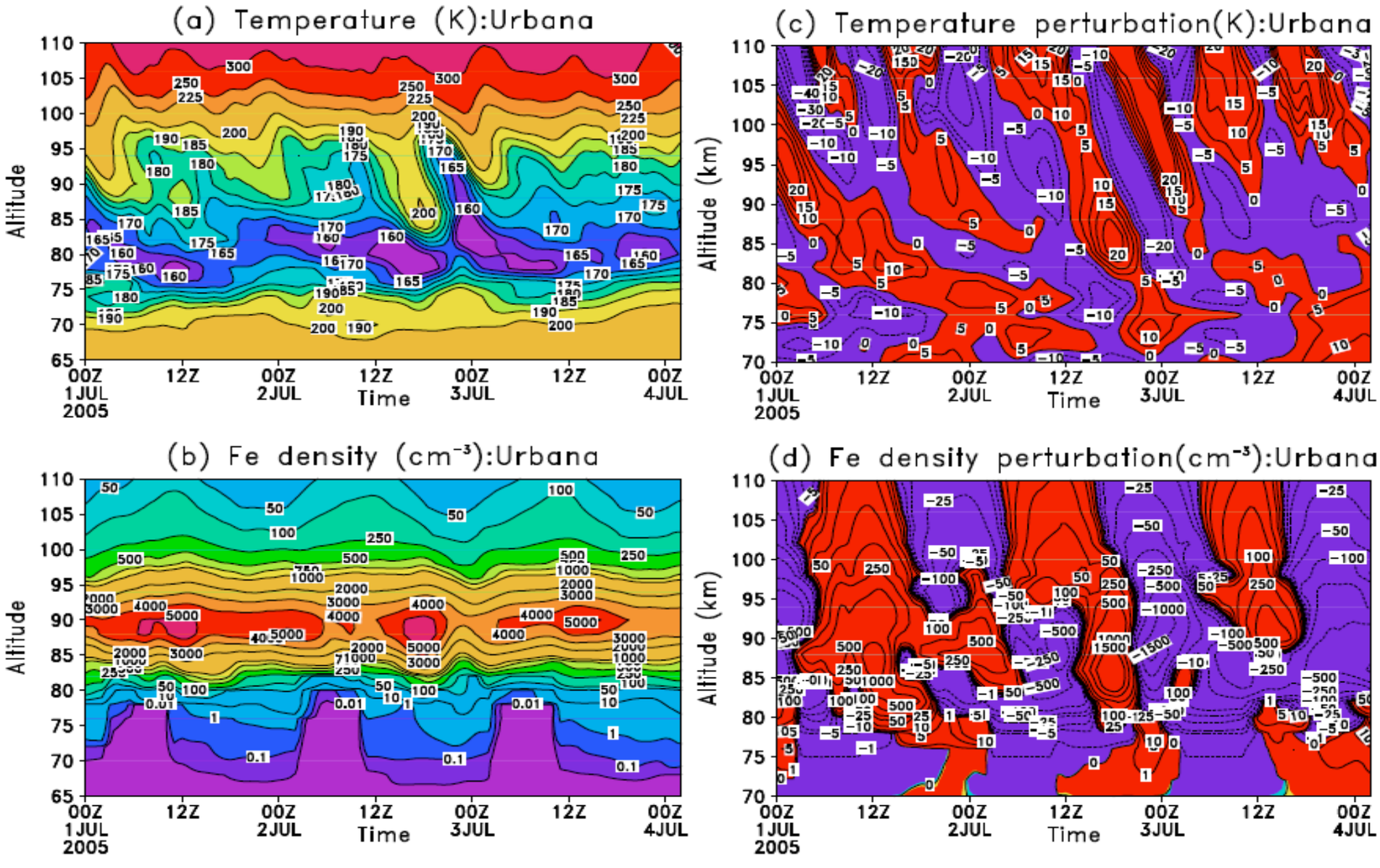


Fe at Davis and South Pole

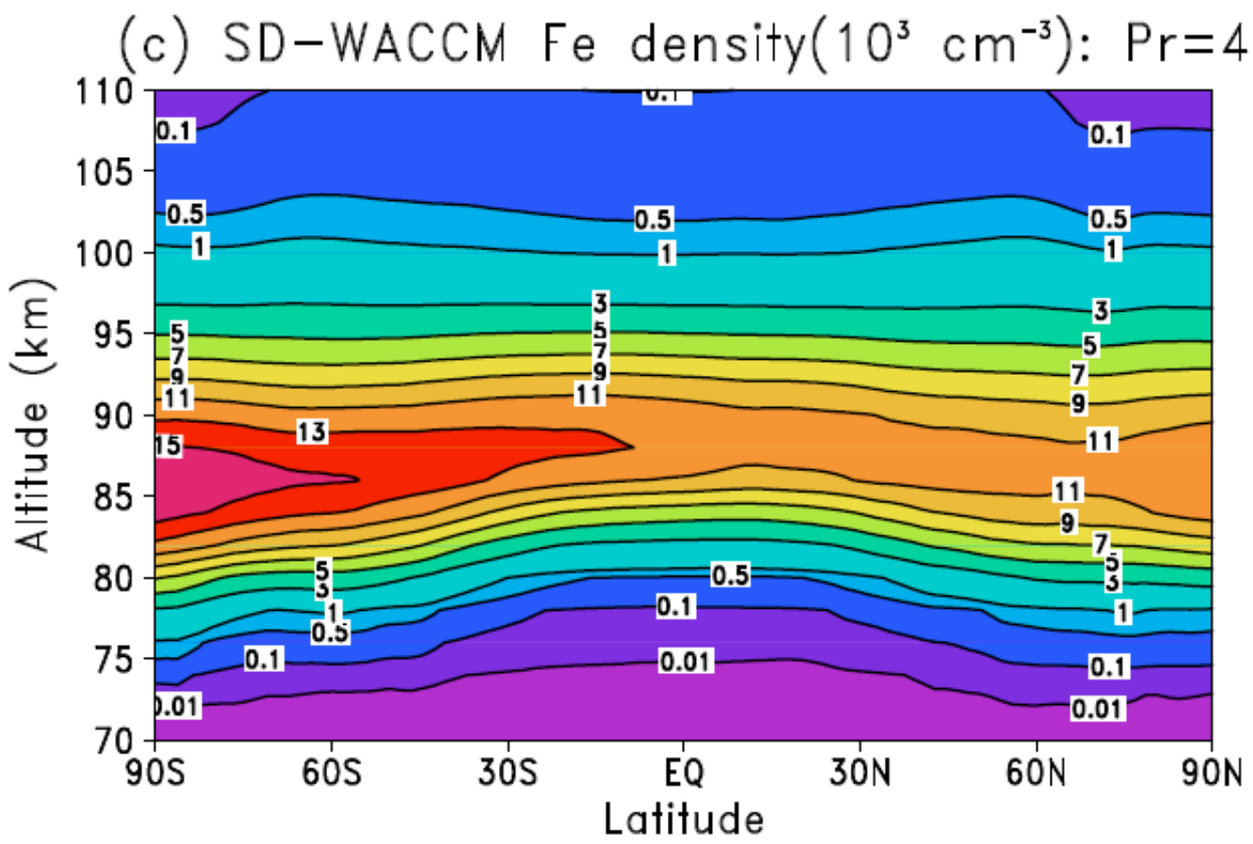


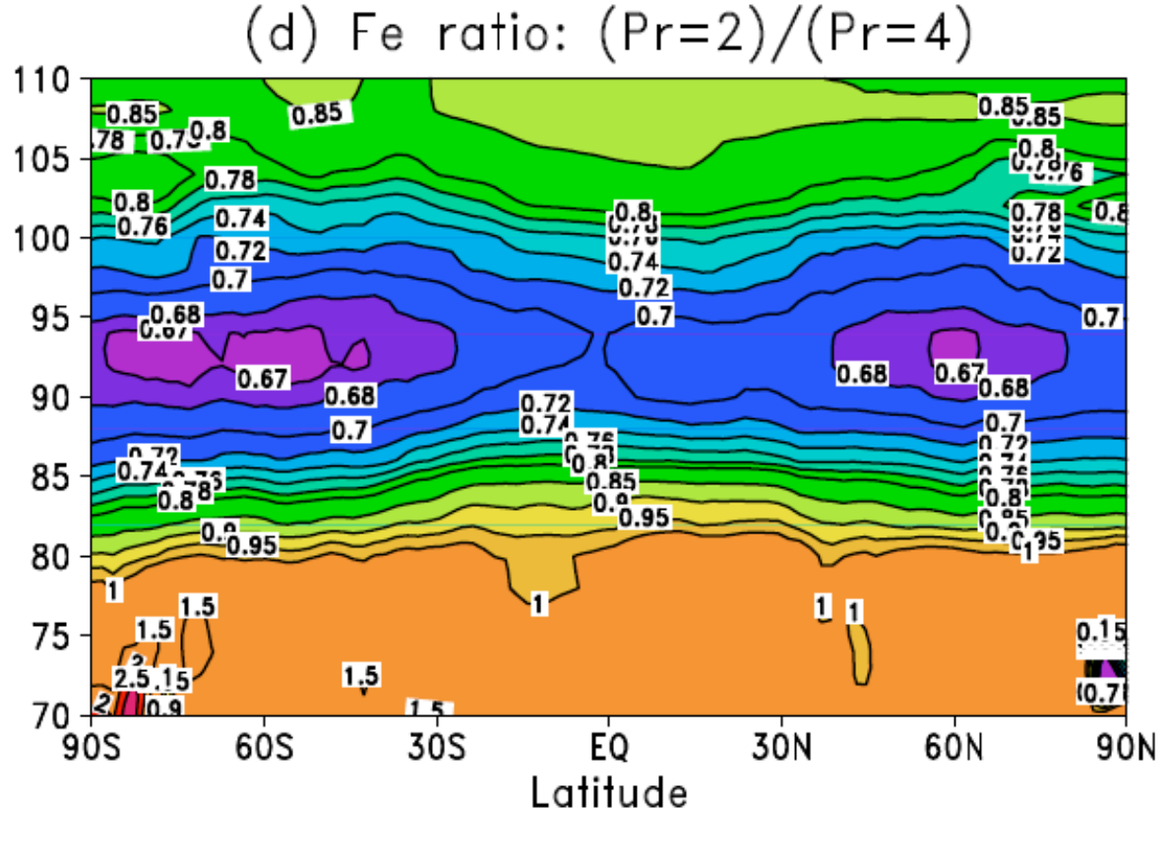
Removal of Fe on polar mesospheric clouds

Diurnal (tidal) signatures in Fe at Urbana



Sensitivity of Fe peak density to eddy diffusion (Kzz)



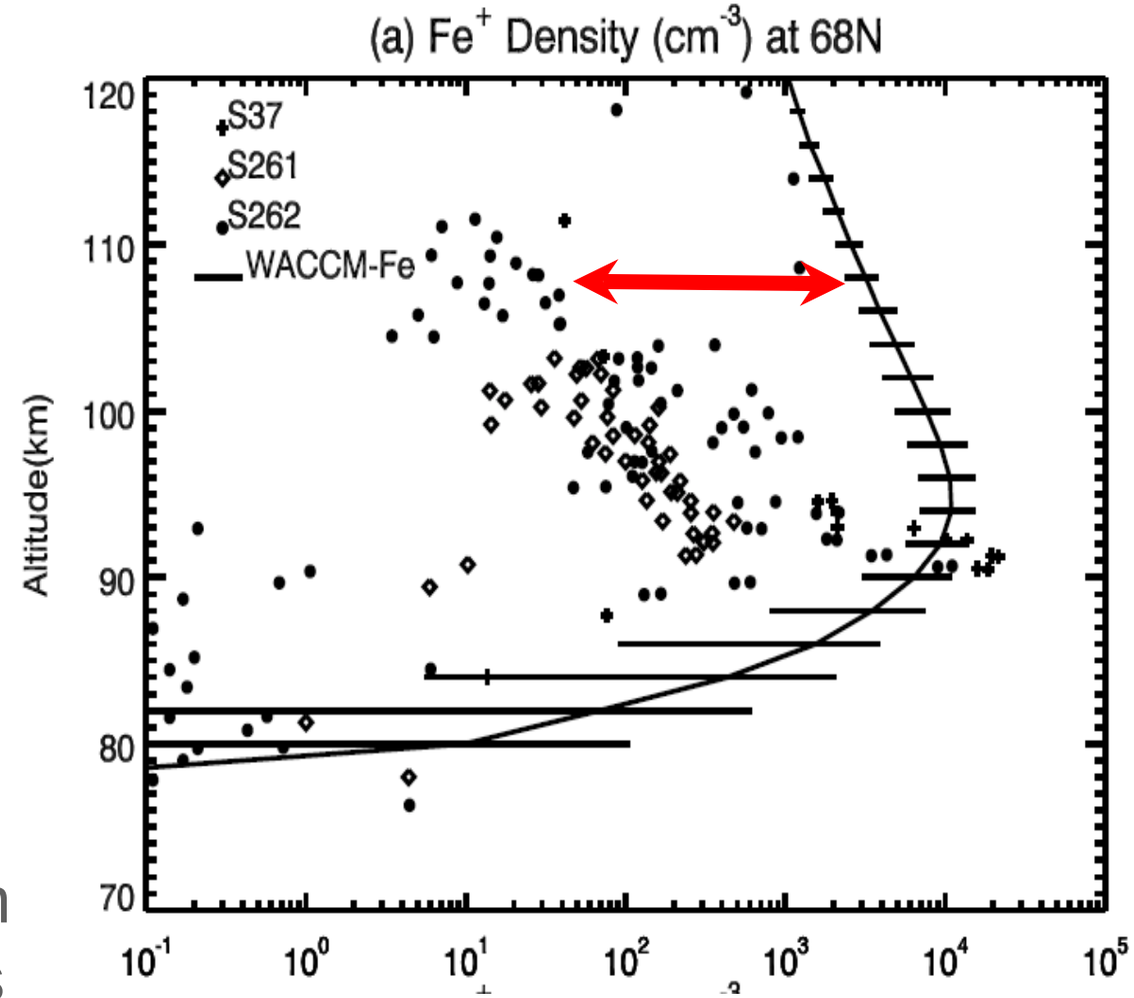


Doubling Kzz reduces peak by 33%

Need to constrain Kzz with CO, CO_2, NOx

Outstanding problems

- Fe+ overestimated by factor of 100 above peak - missing ion transport
- Best match to observations requires different total meteor input:
  - Na: 4.6 t/d, Fe: 2.1 t/d
- Prandtl needs to be set to minimize differences between observed metals, other constituents and temperature
- PMC to low and prevalent - GW fluxes in error. Tuning for the stratosphere makes things even worse!



IDPs as a source of bioavailable iron for remote ocean

Interplanetary Dust Particles ✓

↓

Ablation ✓

↓

Metal Ions/Neutrals ✓

↓

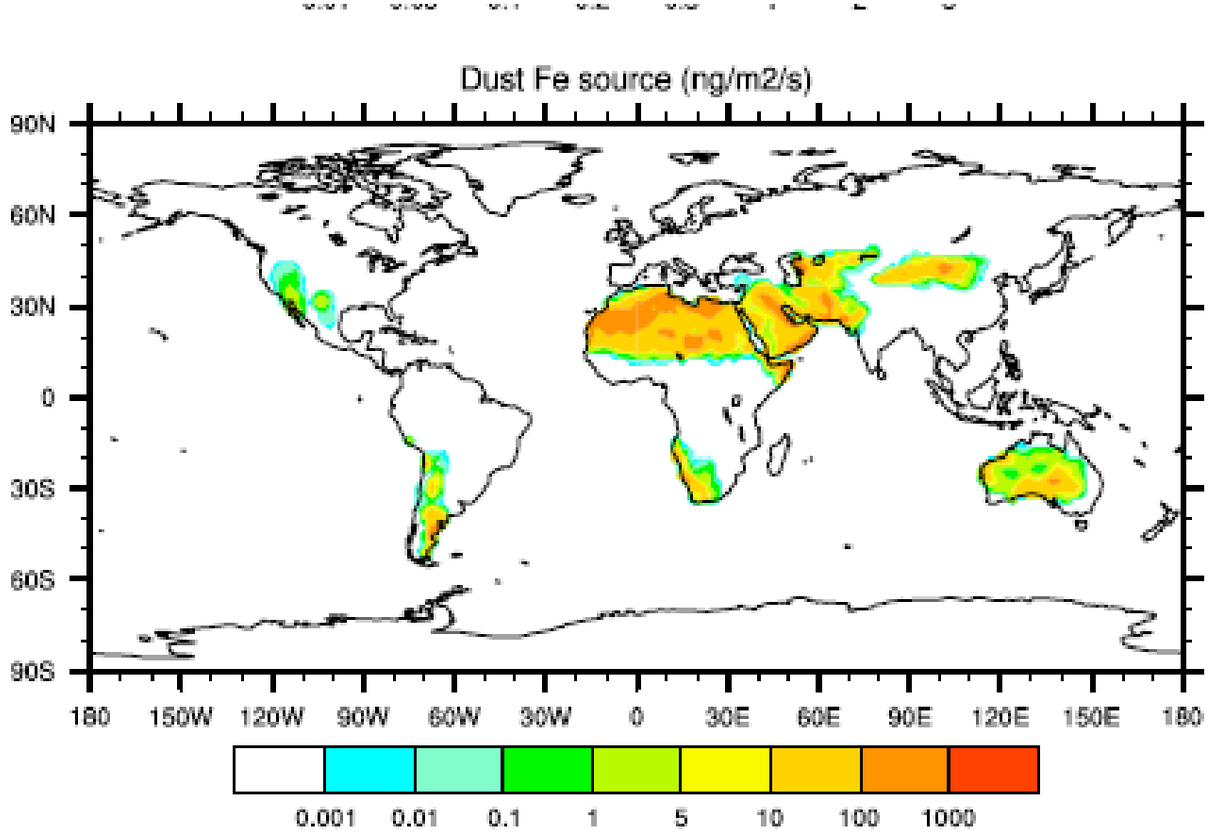
Meteoric Smoke particles

↓

Sulphate aerosols

↓

Wet and dry deposition of Fe
(likely as highly soluble iron sulphate)



Luo et al., 2008

Summary

- The first global models of meteoric sodium and iron have been developed.
- Metals are excellent tracers for middle/upper atmosphere dynamics.
- Provides a further constraints on parameterization of sources and dissipation of gravity waves which drive both the mean circulation and eddy diffusion.
- So far Fe and Na, next Ca, Si, Mg, and K
- We hope to link meteoric Fe with stratospheric sulphate aerosols for the production of bioavailable Fe.

Thank you

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