

A global model of meteoric sodium

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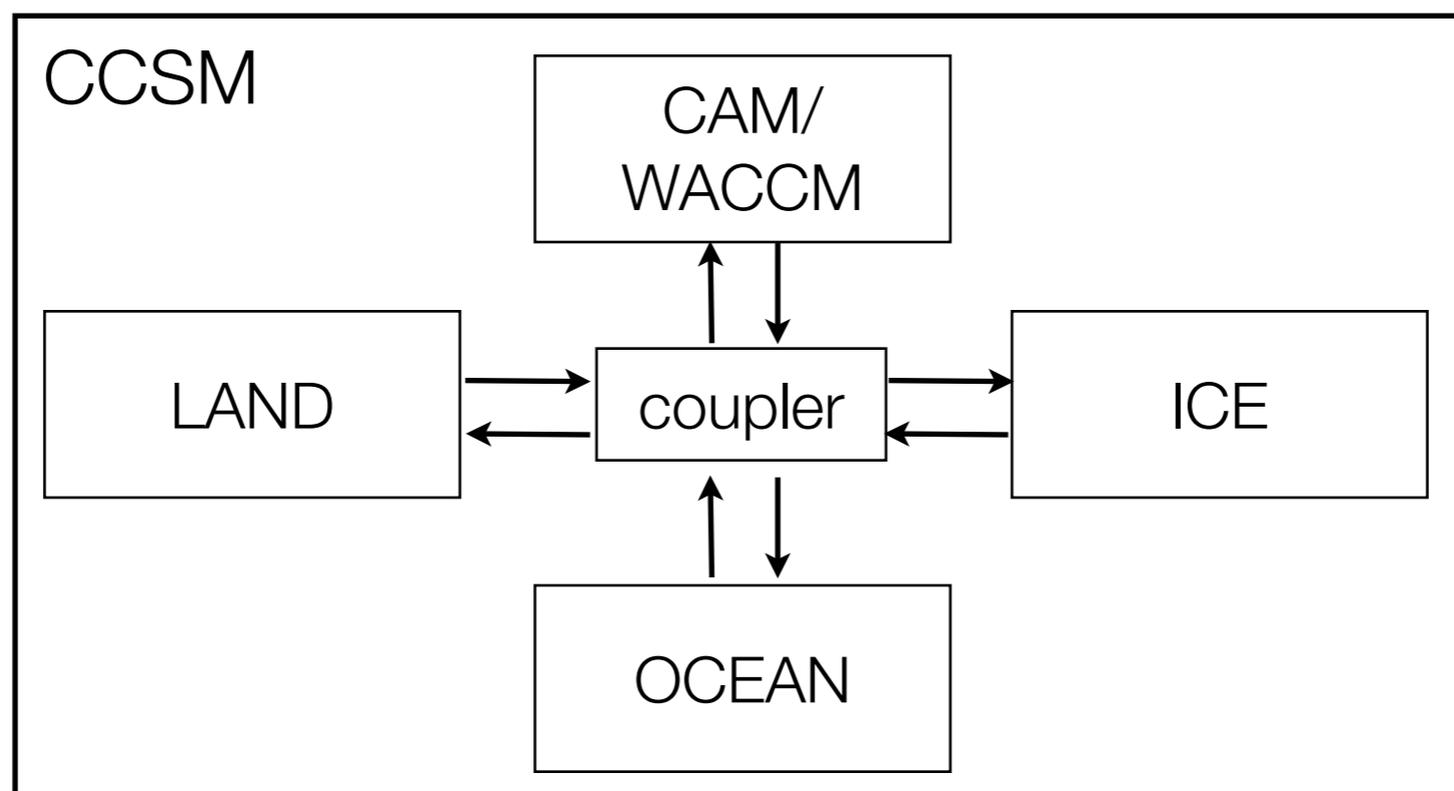
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Whole Atmosphere
Community Climate Model



WACCM 4.0

- WACCM is an extension of the Community Atmosphere Model (CAM) - the atmospheric component of the Community Climate System Model



Current simulations use observed climatological SSTs and sea ice for solar maximum conditions

Atmospheric Model description

Dynamics	Tracer Advection	Resolution	Other Processes
<p>Finite Volume Dynamical Core (Lin, 2004)</p> <p>Fully-interactive with chemistry, i.e., consistent with model-derived, radiatively active gases:</p> <p>O₃, CO₂, CH₄, N₂O, H₂O, CFC11, CFC12, O₂, NO</p>	<p>Flux-form Finite Volume (Lin, 2004)</p>	<p>Horizontal: 1.9° x 2.5° (lat x lon)</p> <p>Vertical: 66 levels 0-140km</p> <p>< 1.0km in UTLS 1-2 km in stratosphere ~3 km in MLT</p>	<p>GW Param.: convection-, frontal-, and orographically-generated</p> <p>Molecular Diffusion: Banks and Kockarts, 1973</p> <p>Auroral processes, including ion drag, and Joule heating</p> <p>LW/SW and chemical potential heating</p>



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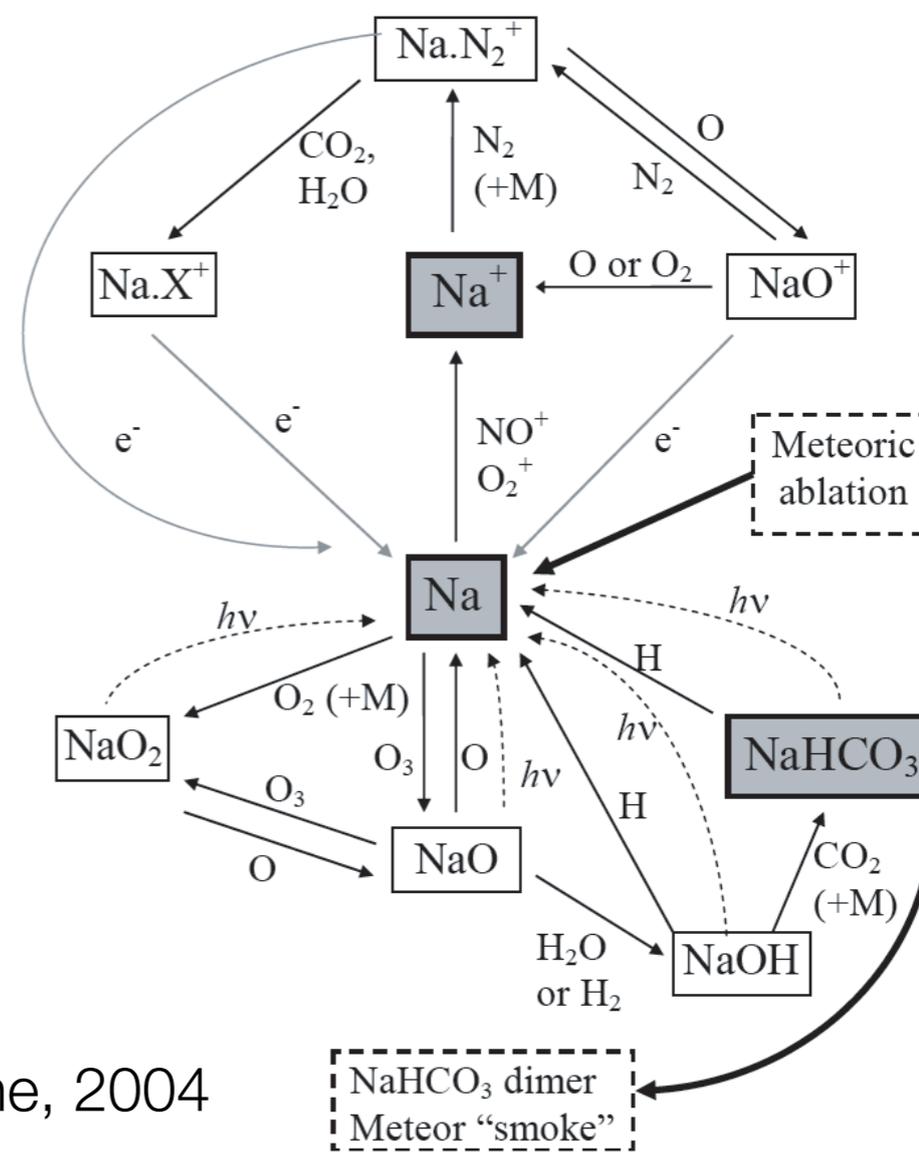


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Chemistry Scheme

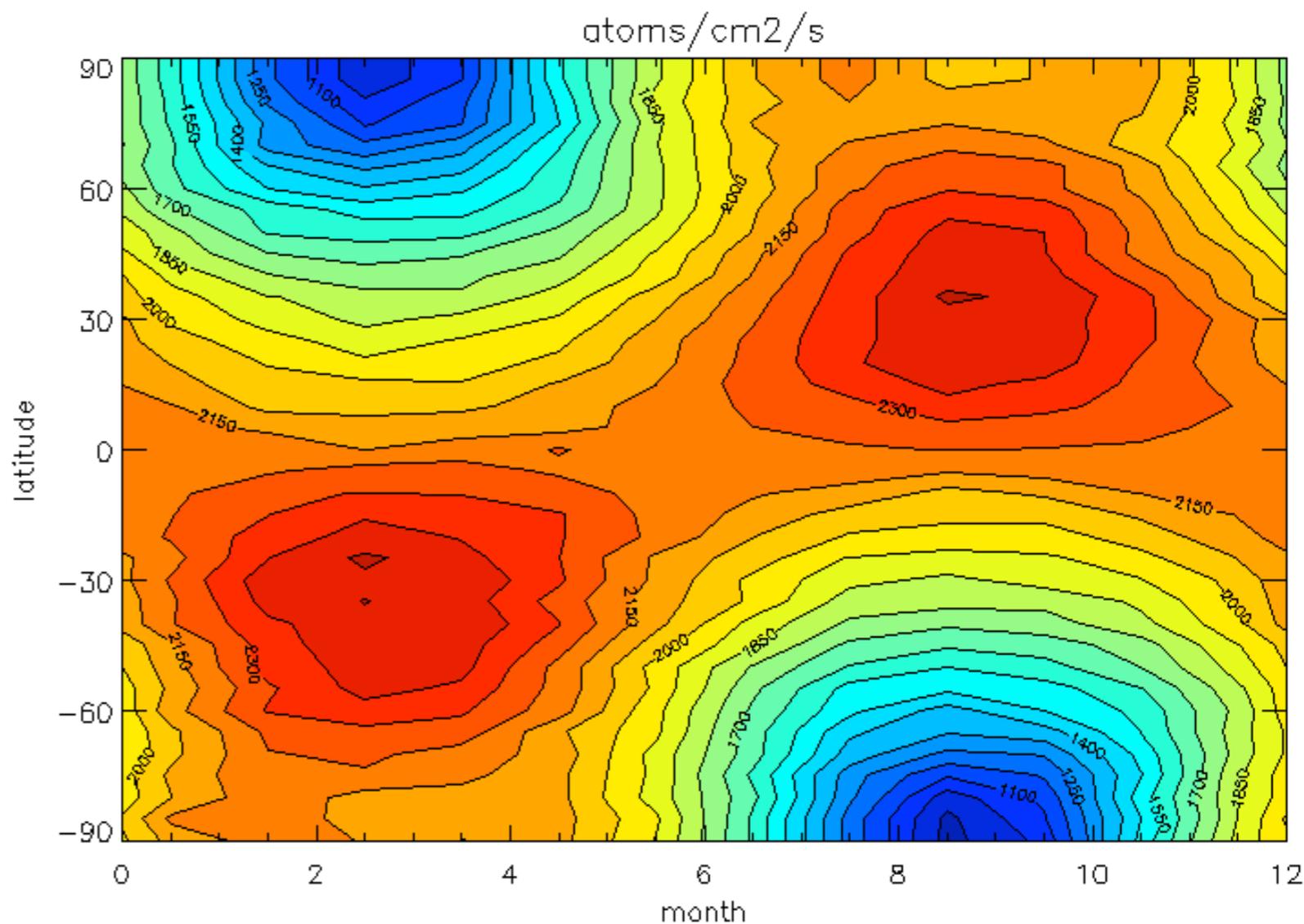
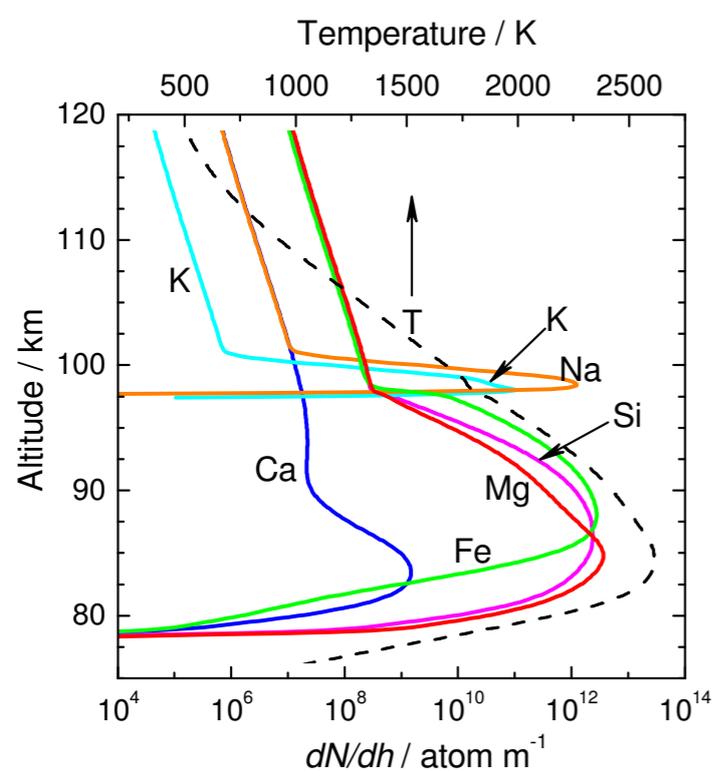
- 66 Species including Ox, HOx, NOx, BrOx, and ClOx
- Heterogeneous chemistry
- E-region ion chemistry
- Na Chemistry follows Plane [2004]
 - Na^+ , Na, NaCO_2^+ , NaH_2O^+ , NaHCO_3 , NaN_2^+ , NaO, NaO_2 , NaOH
 - 26 Na chemical reactions
 - 5 photolysis reactions



Plane, 2004

Na Meteoroid Input Function (MIF)

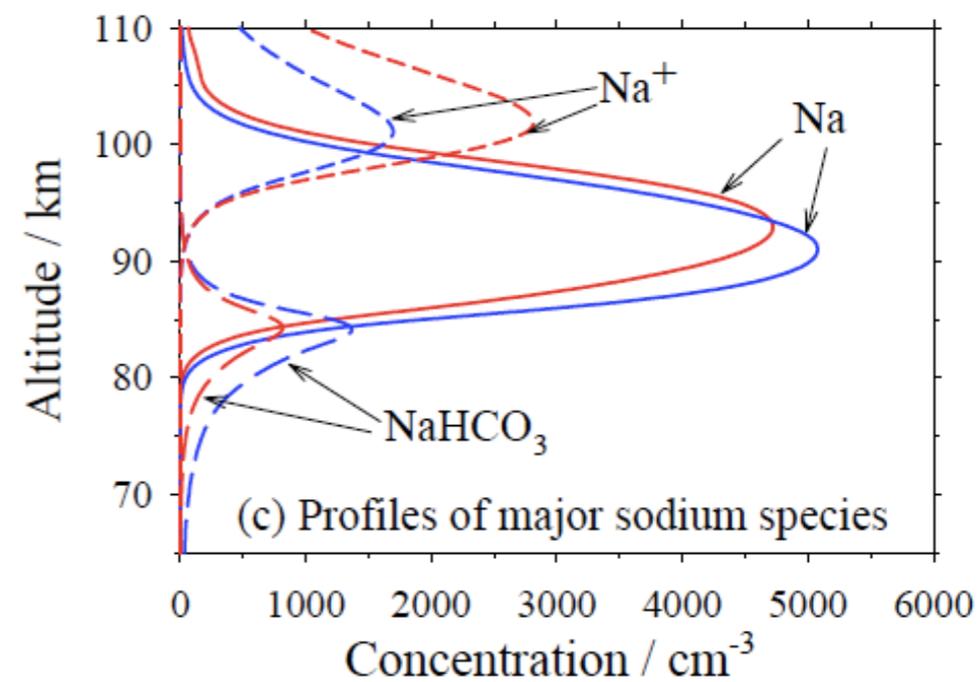
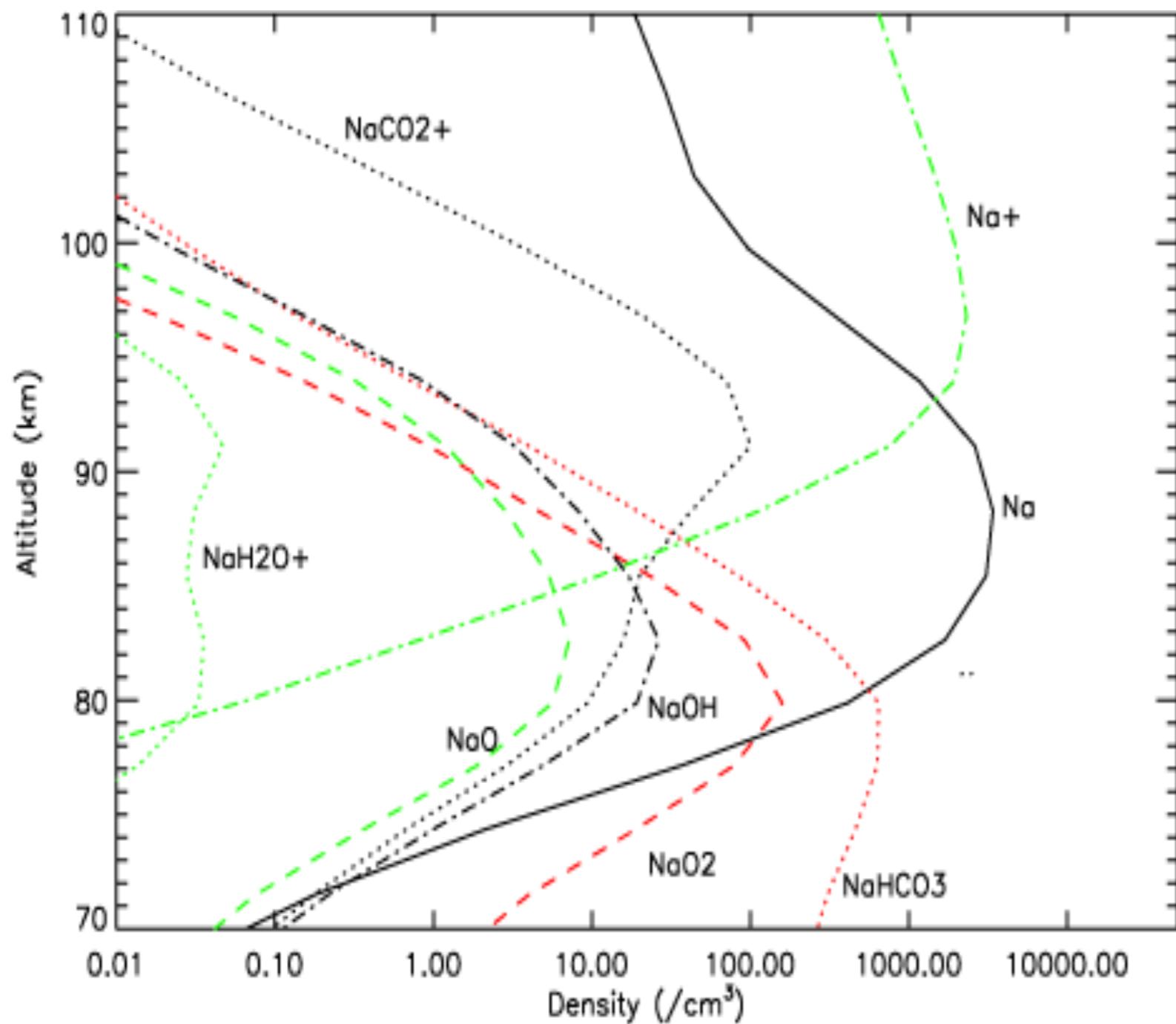
An astronomical model of meteoroid fluxes (CoRA) is combined with a chemical ablation model (CABMOD - Leeds) to provide a climatology of Na deposition



MIF scaled to give 6t/d global/annual average

Global mean Na species altitude profiles

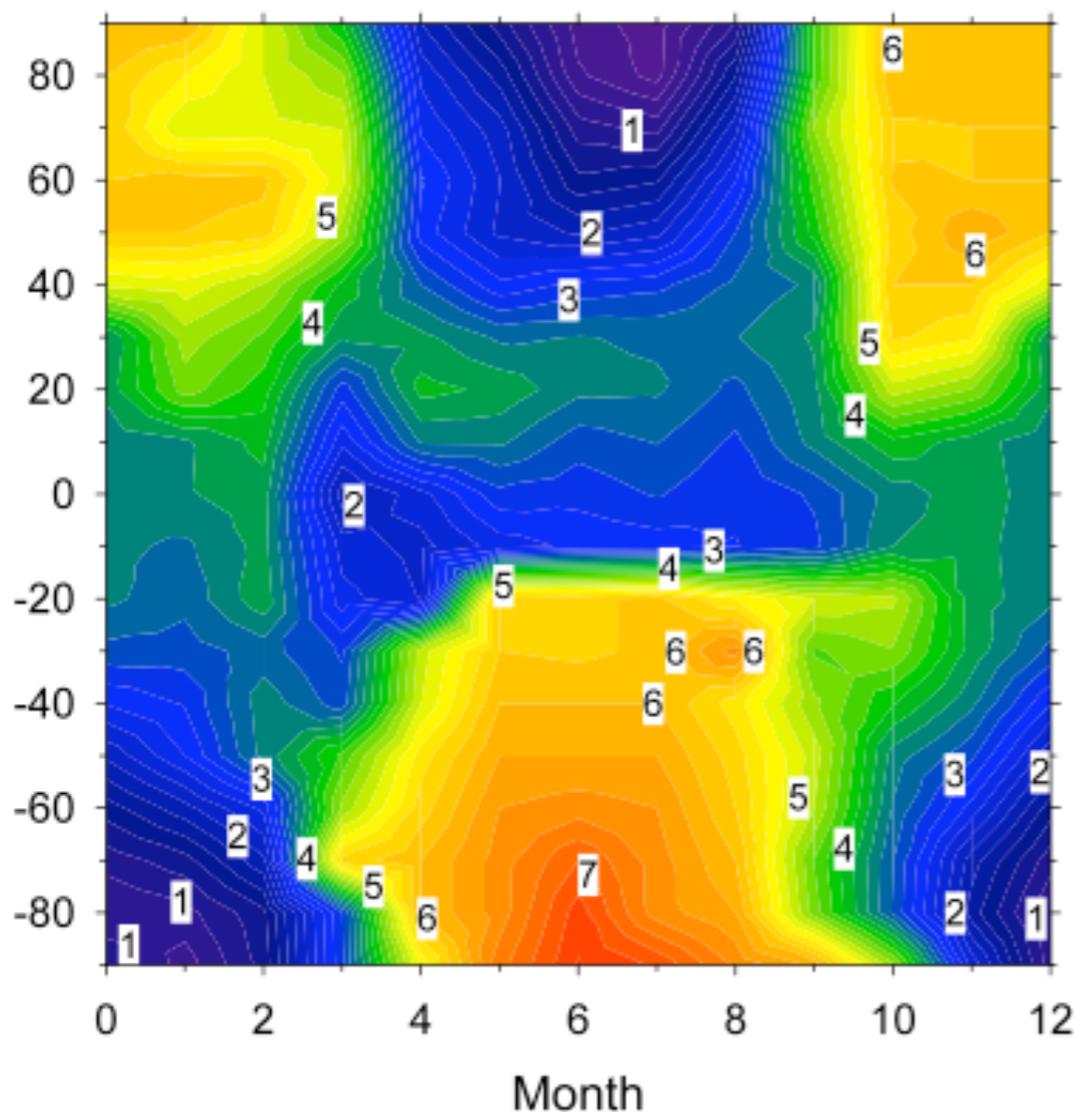
WACCM June



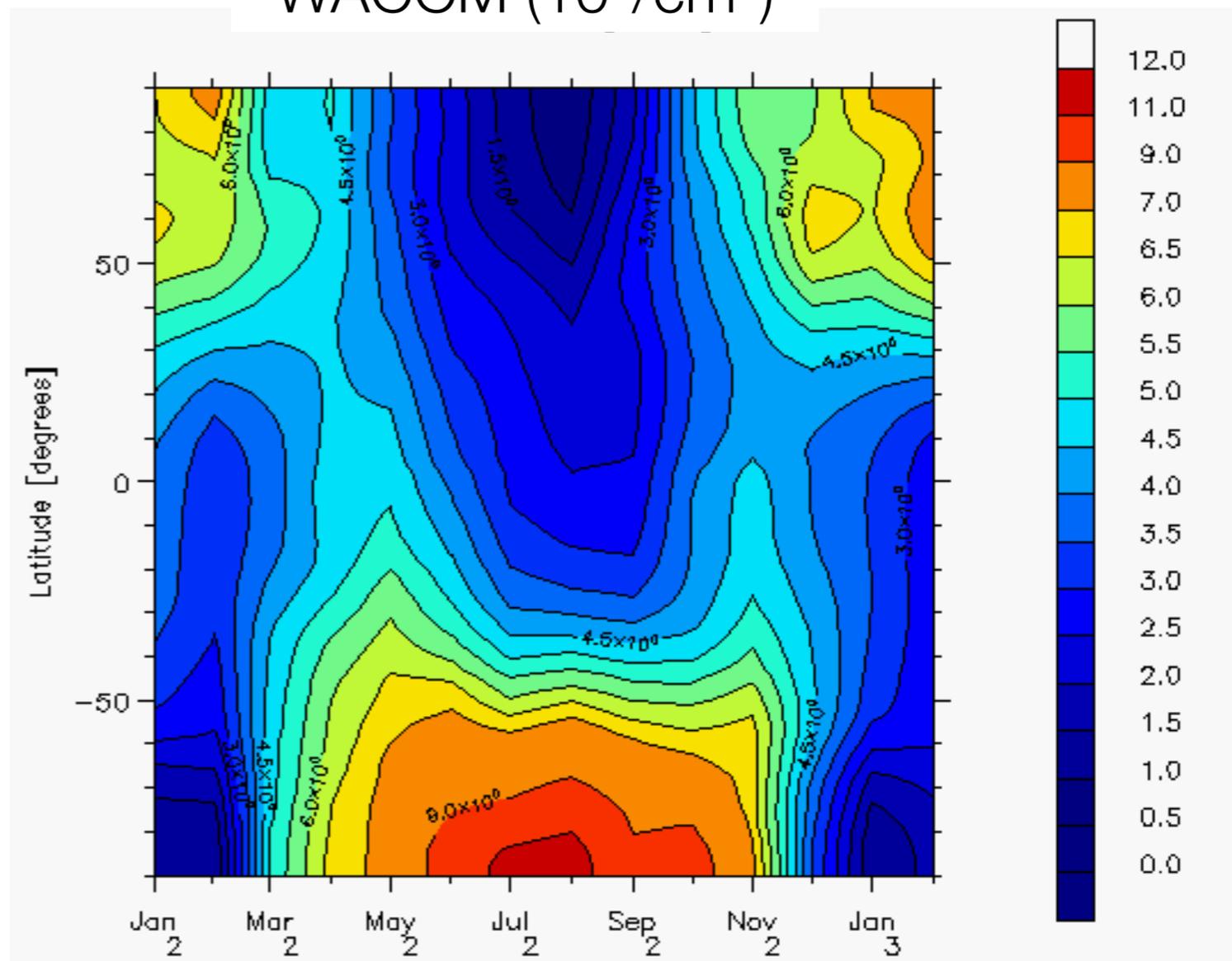
Plane, 2004

Seasonal variation of Na column density

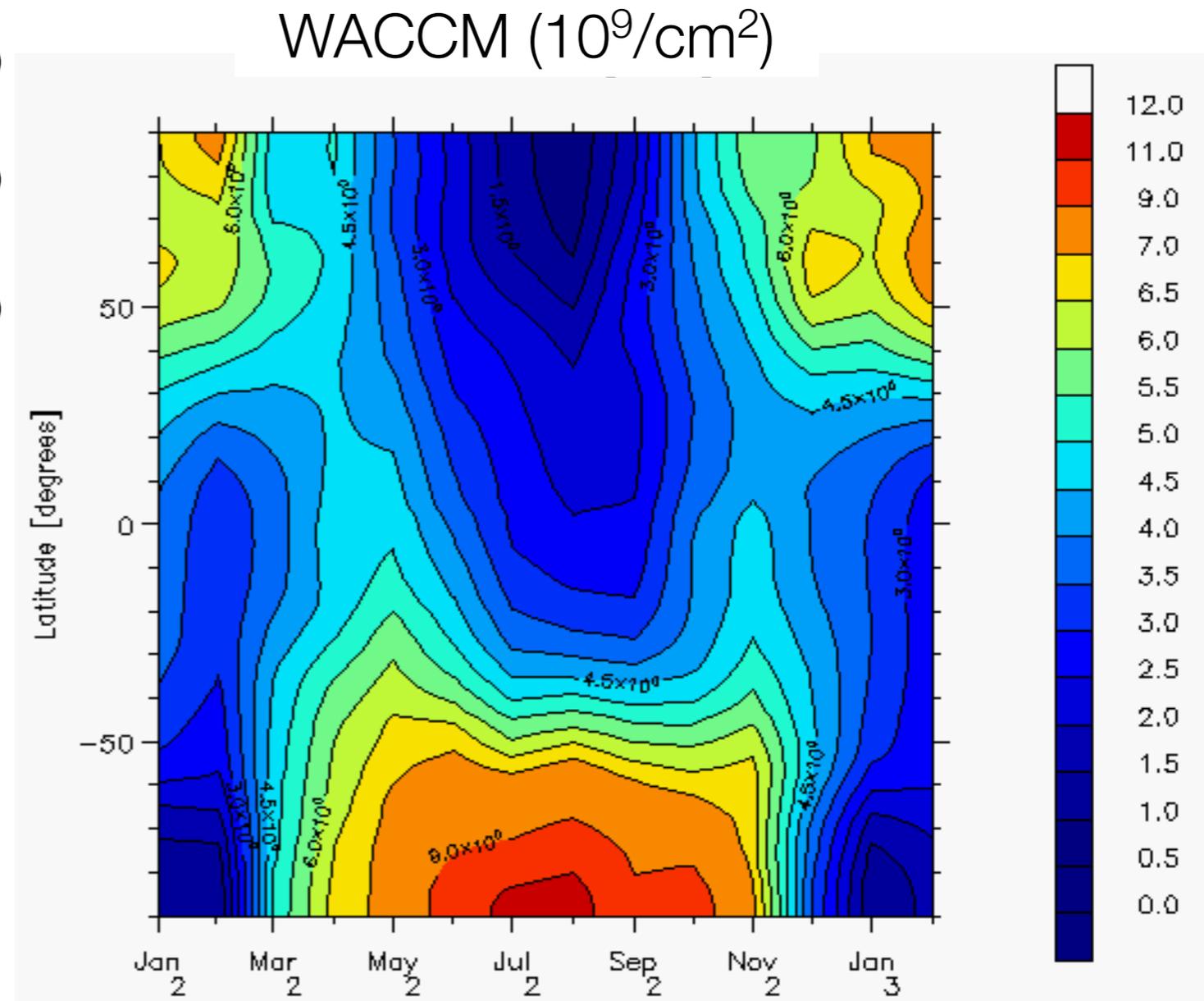
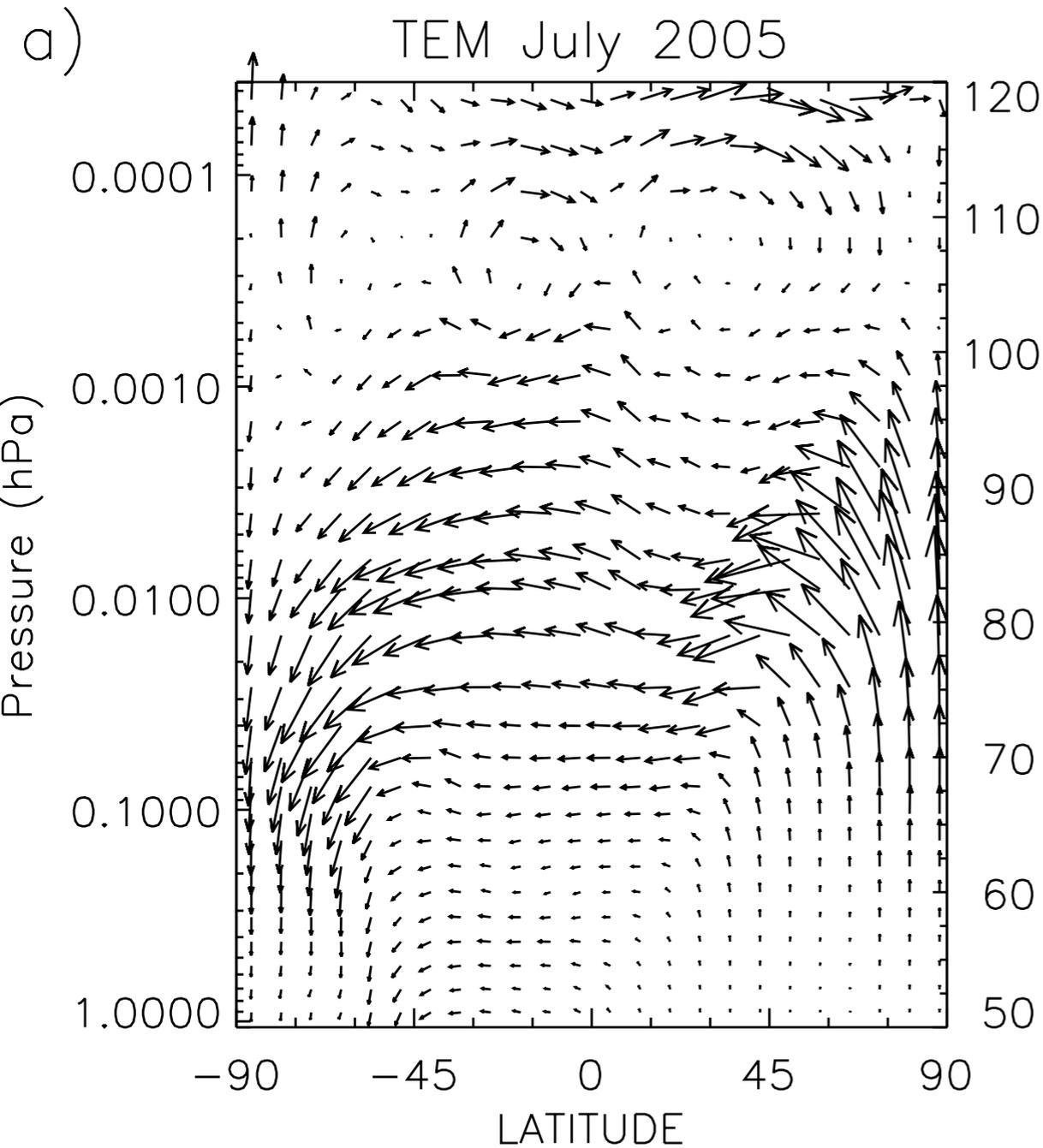
Osiris ($10^9/\text{cm}^2$)



WACCM ($10^9/\text{cm}^2$)

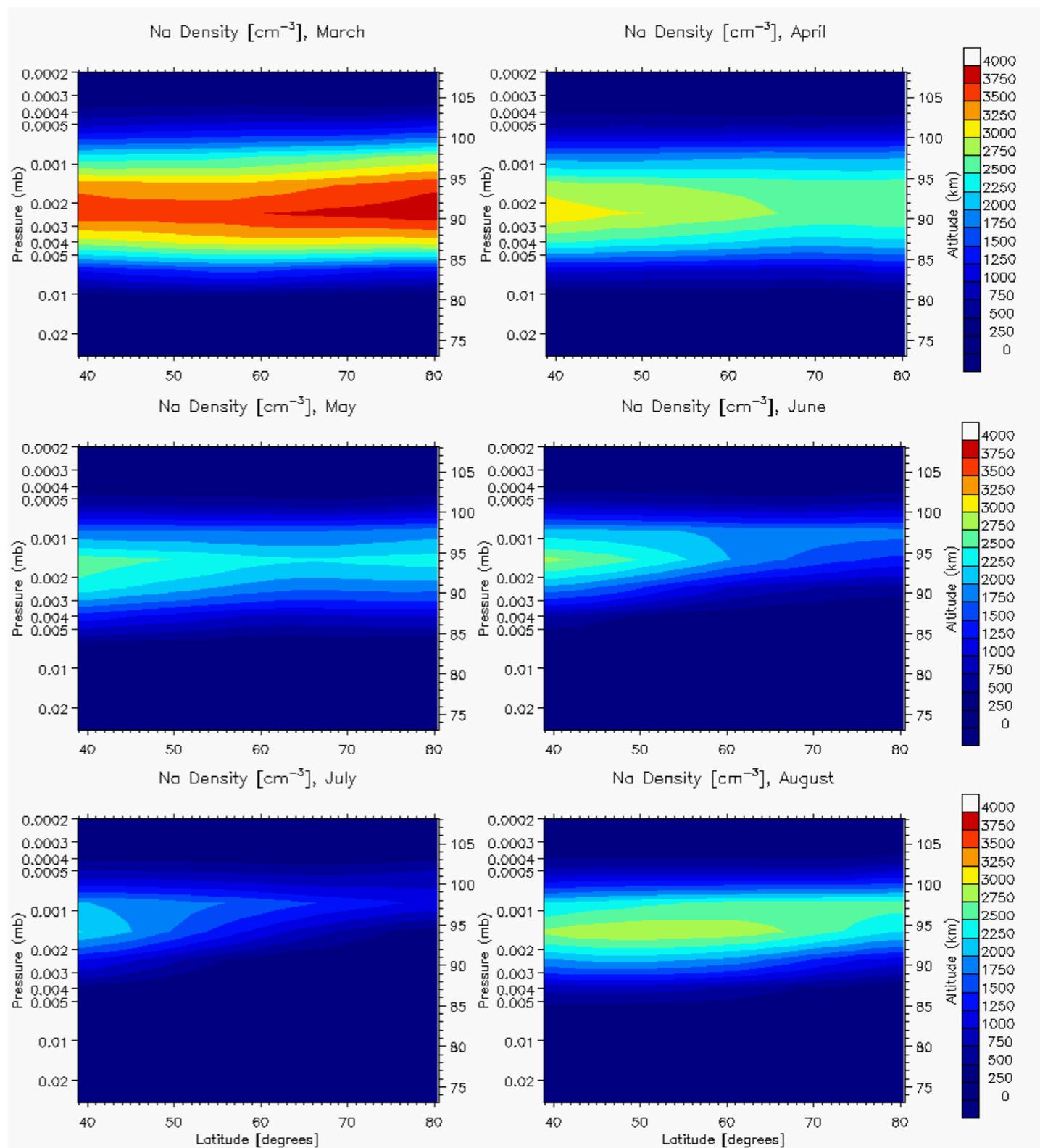
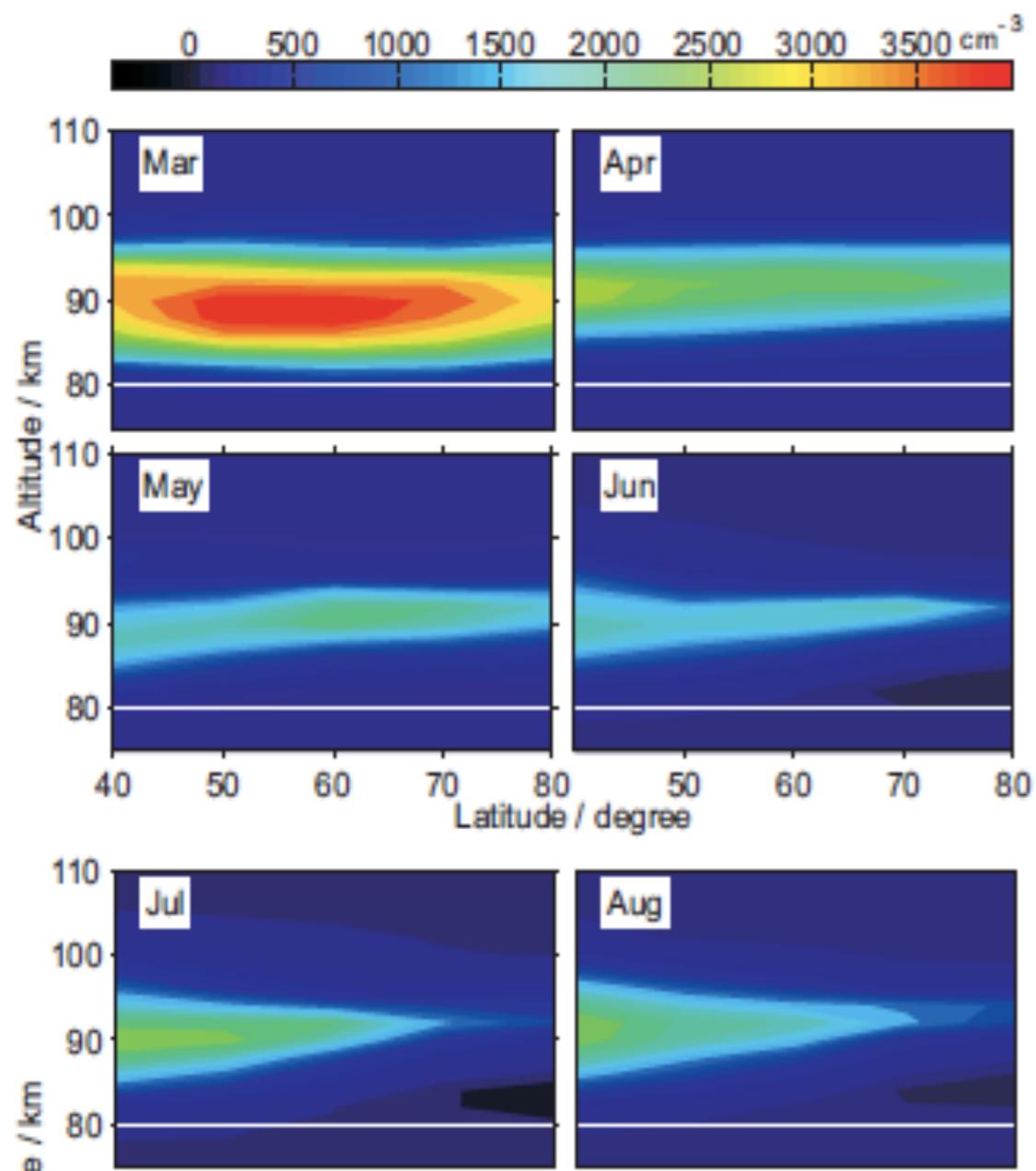


Residual circulation drives seasonal variation



Seasonal variations

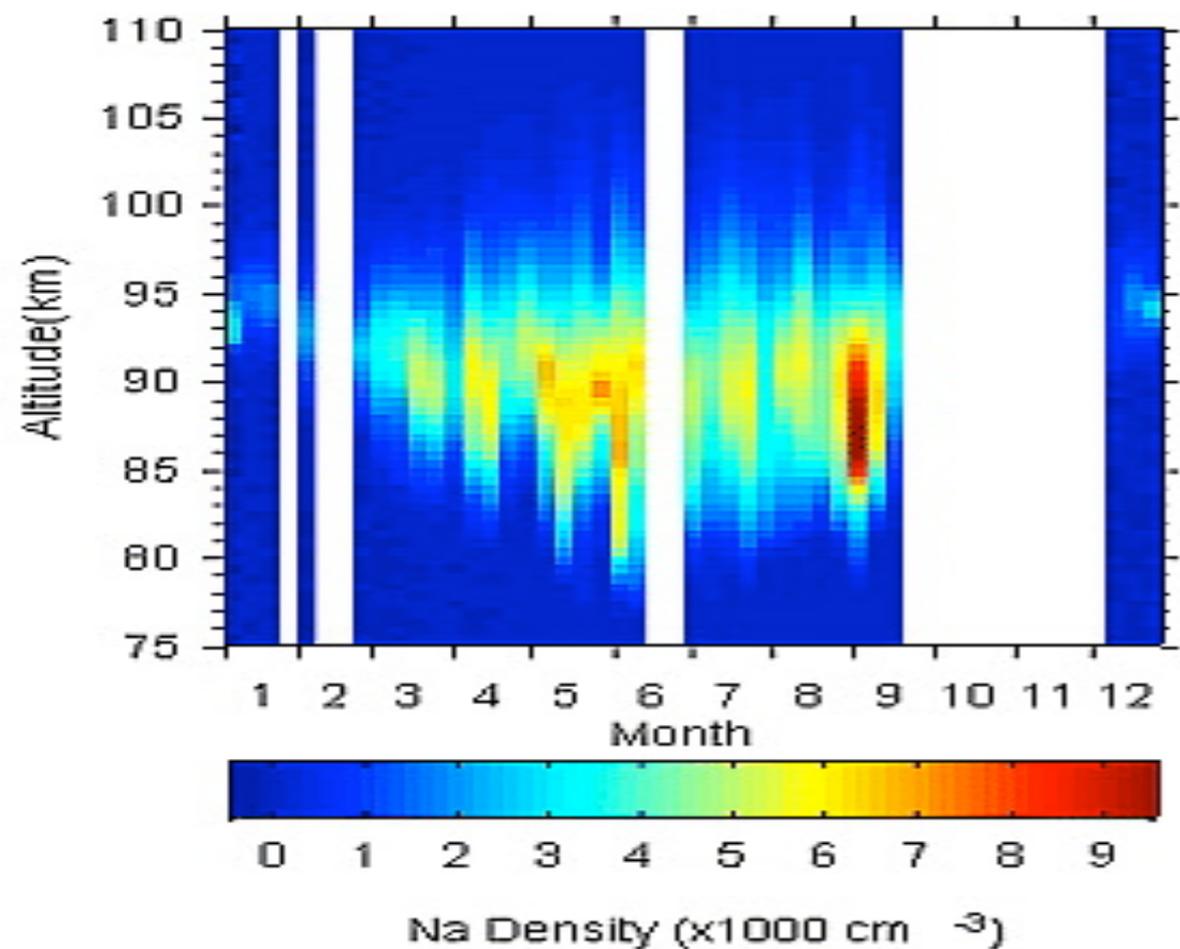
Osiris (atoms/cm³)



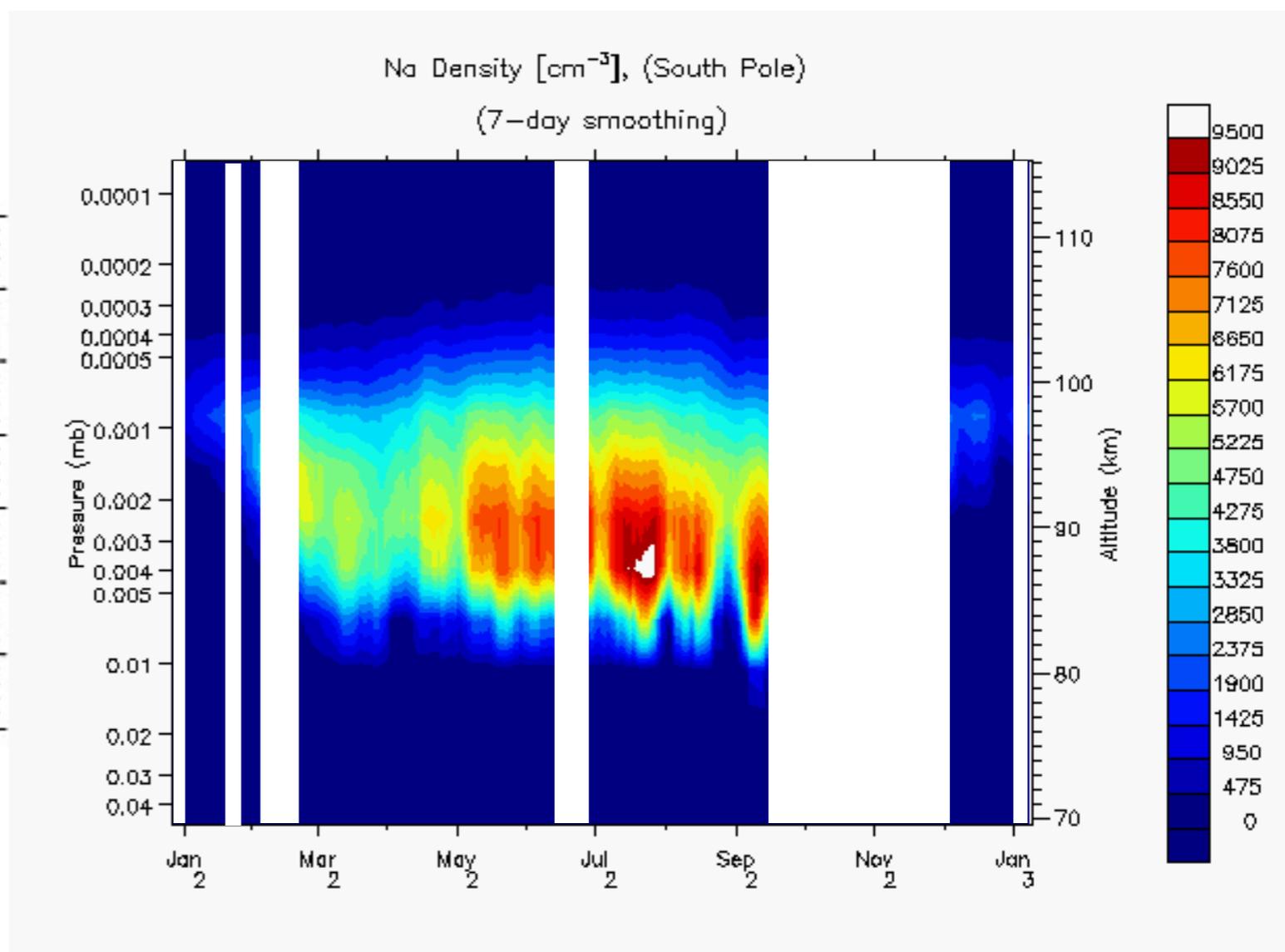
Fan et al., 2007

South Pole - weekly densities (cm^{-3})

LIDAR



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Gardner et al., JGR-D 2005



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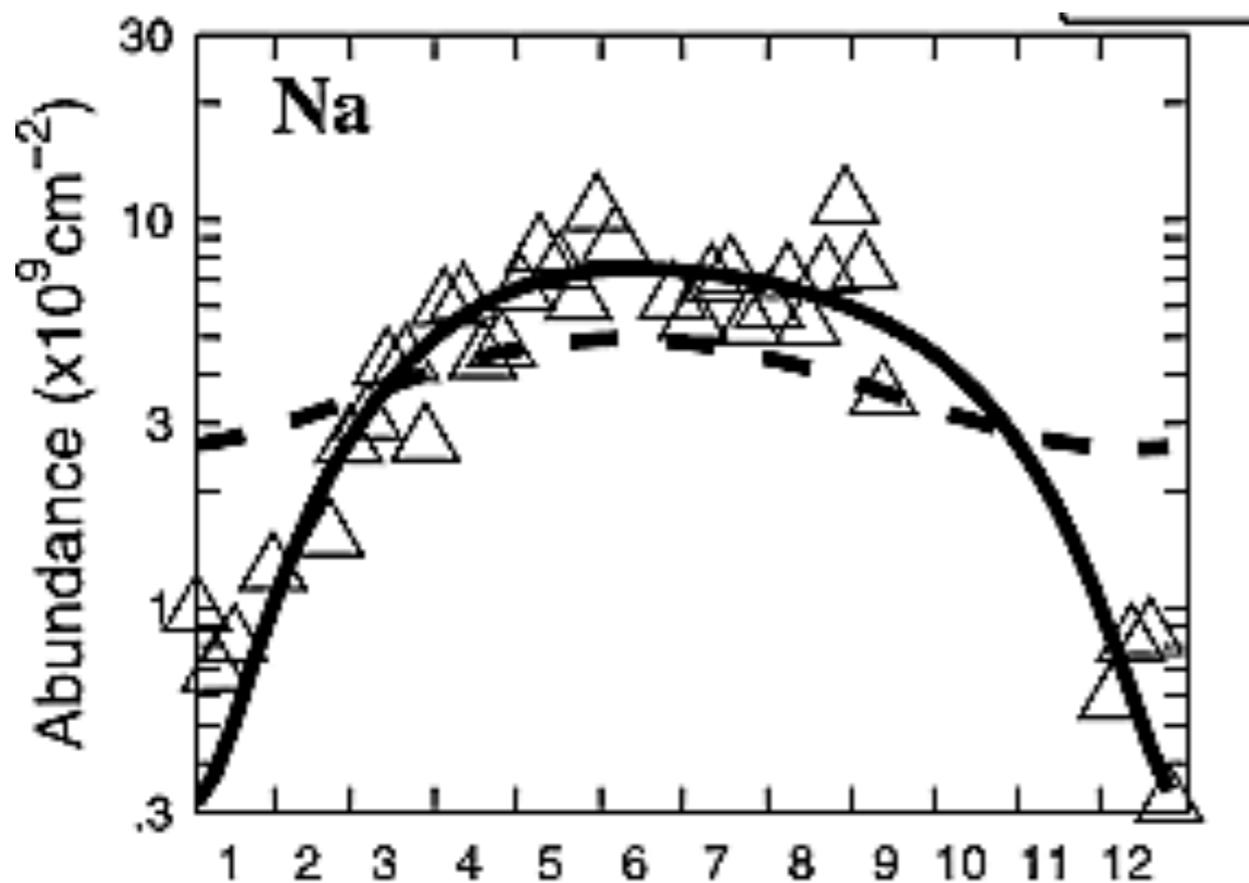
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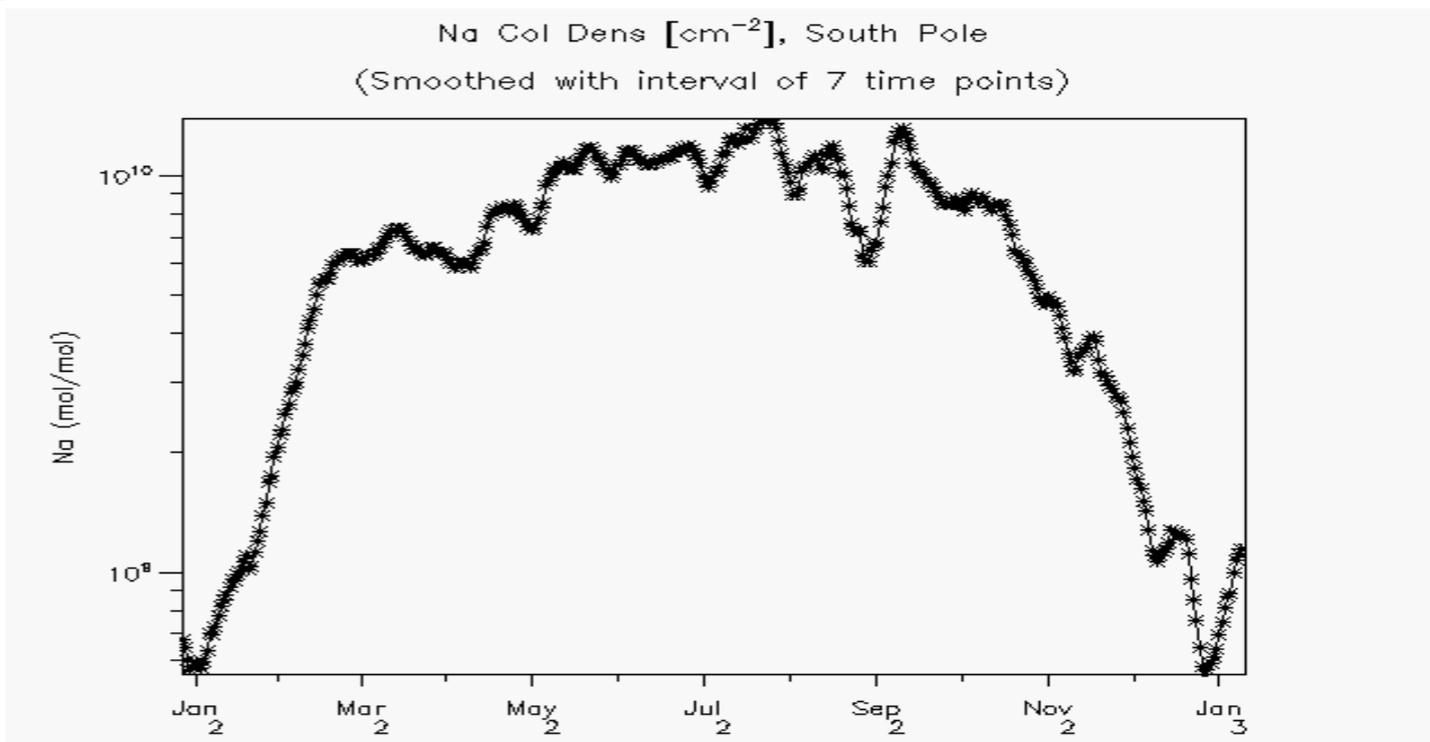


South Pole - column densities (cm^{-2})

LIDAR



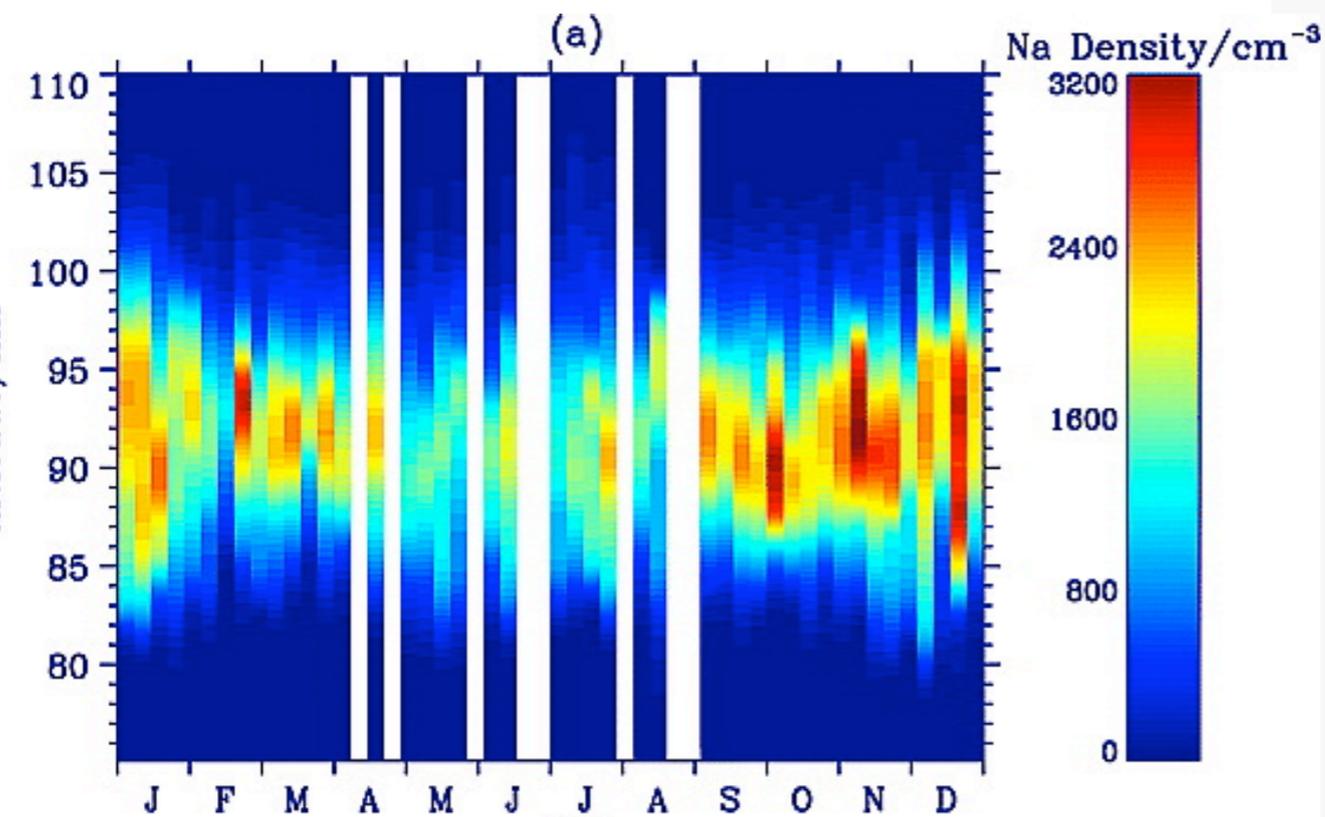
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Gardner et al., JGR-D 2005

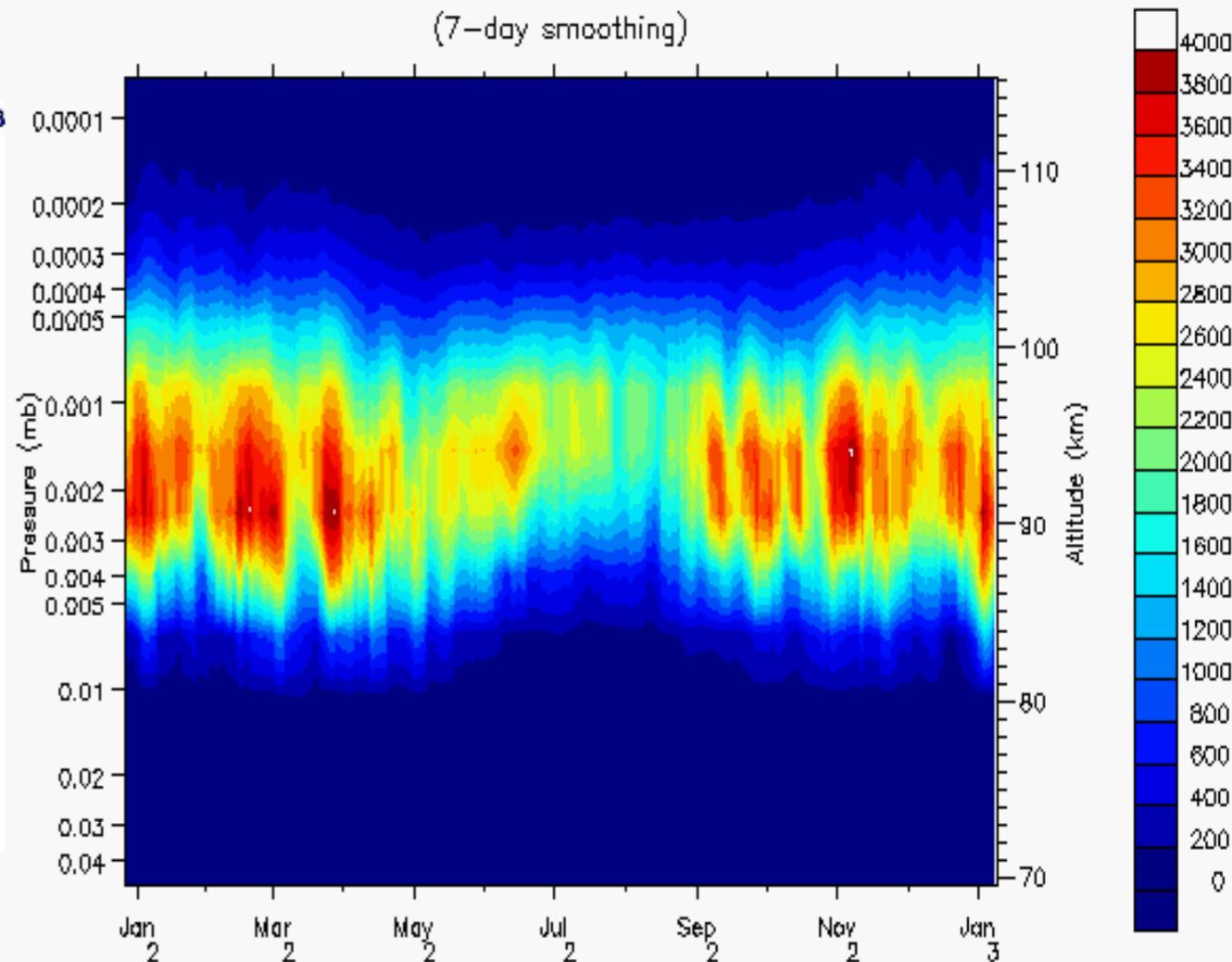
Wuhan, China (115°E, 30°N)

LIDAR



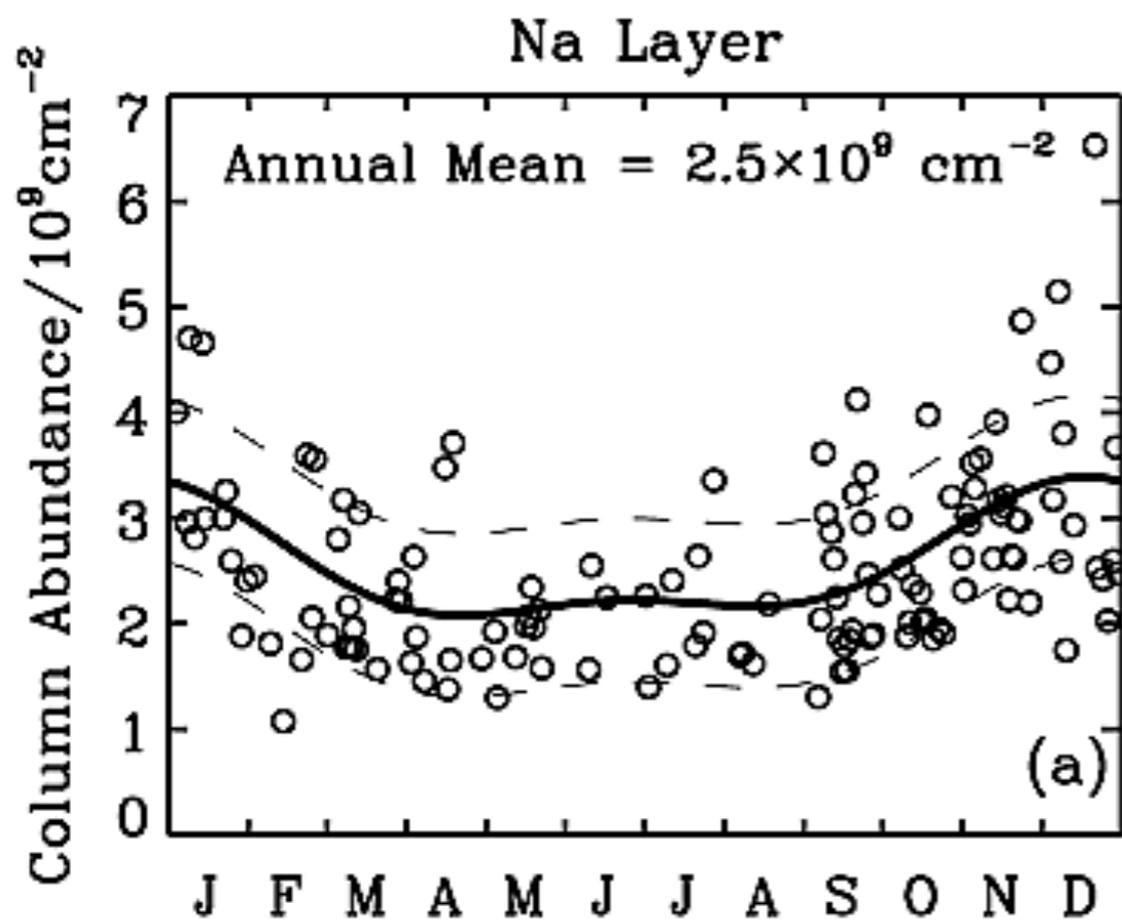
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Na Density [cm⁻³], (115 E, 29 N)
(7-day smoothing)

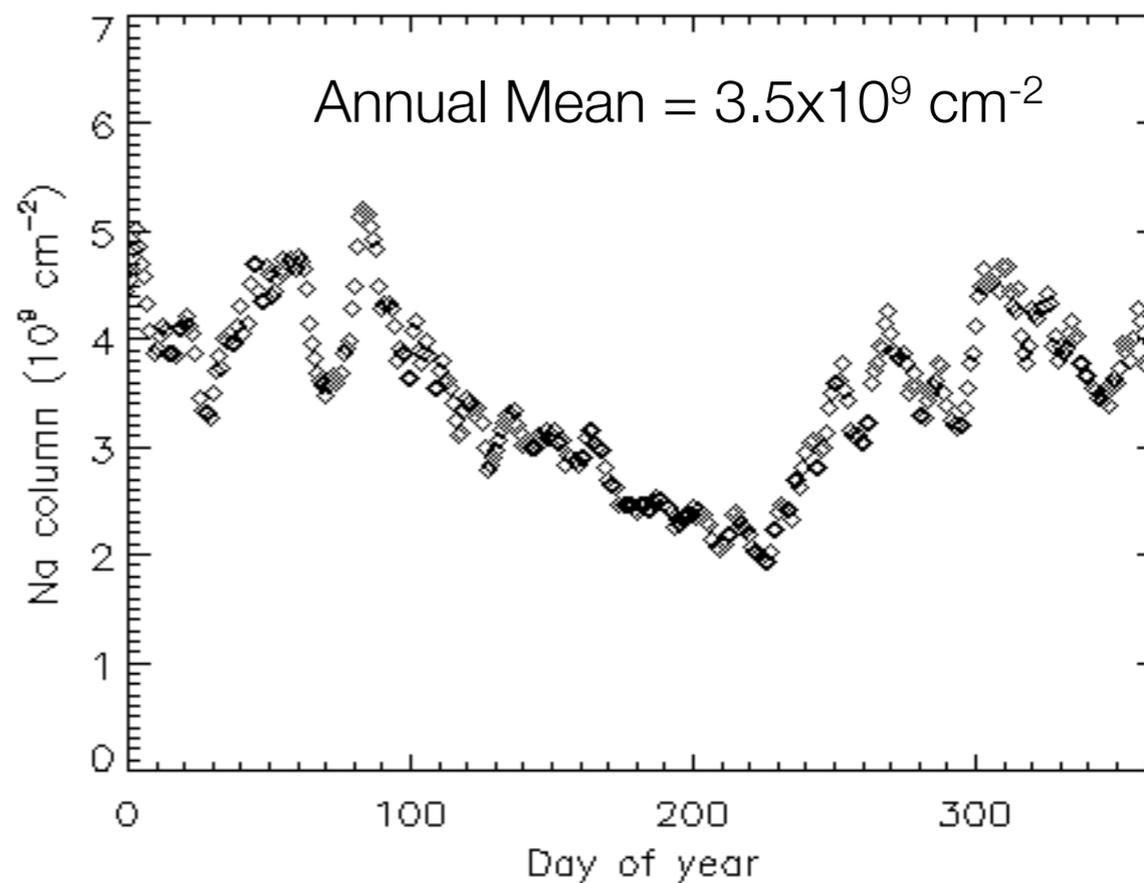


Fan Yi et al., JGR-D, 2009

Wuhan, China (115°E, 30°N)

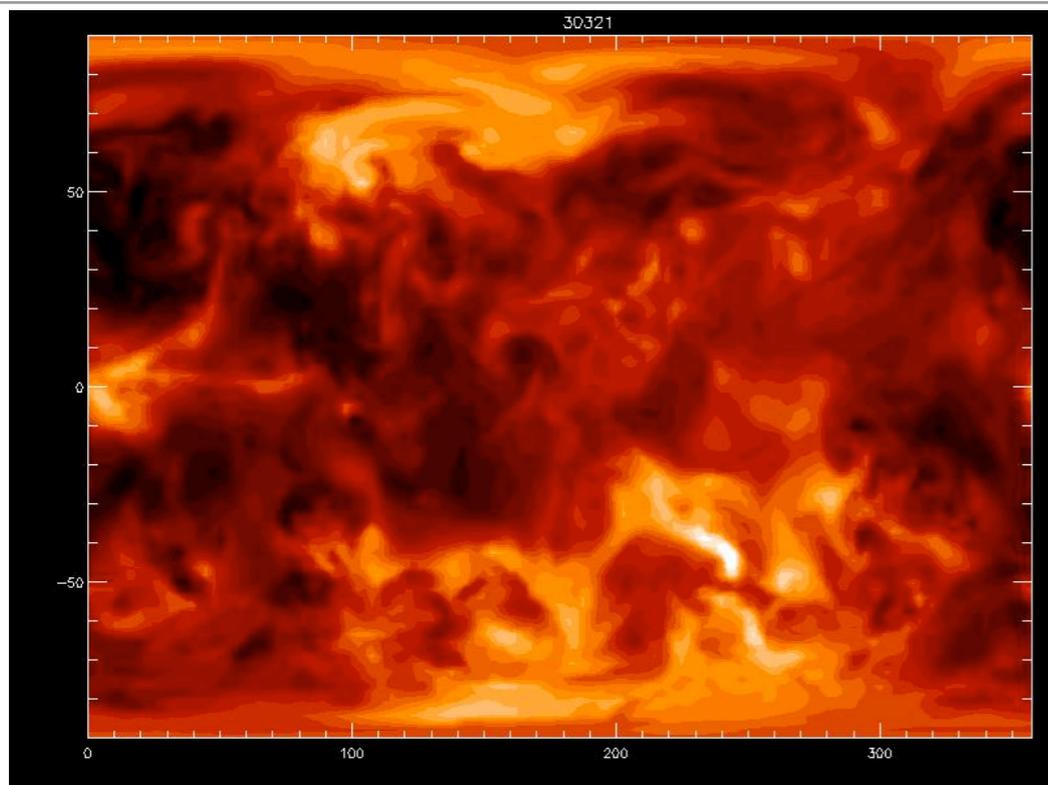


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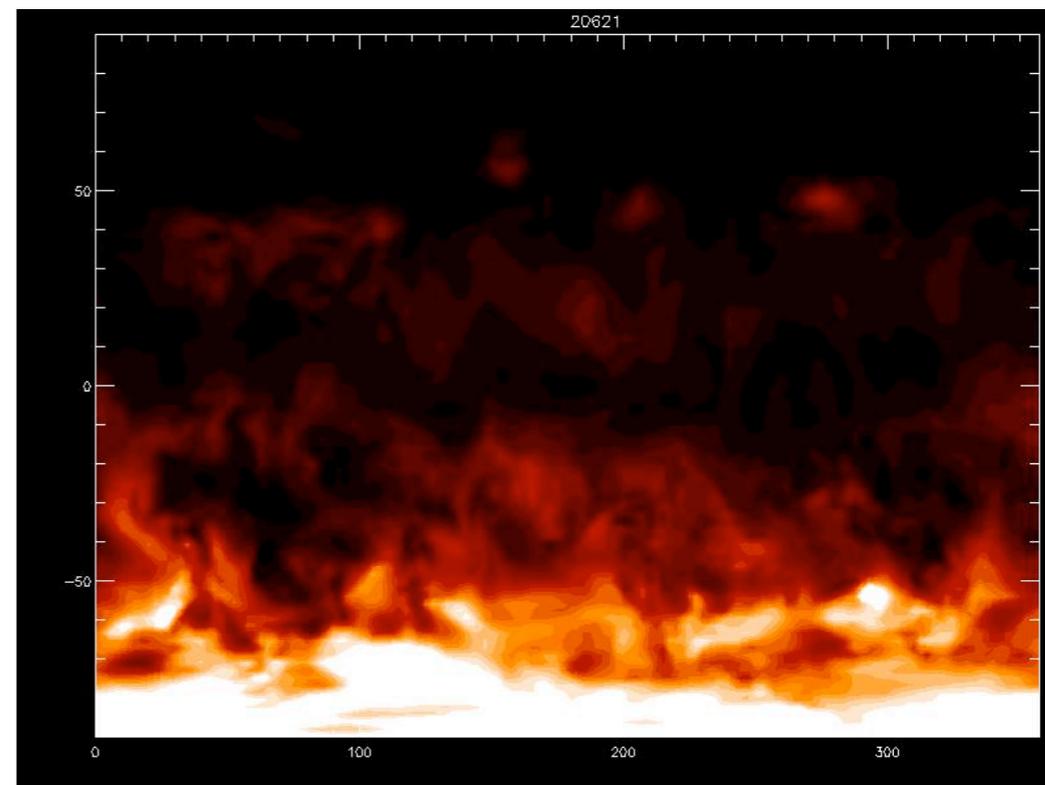


Na density snapshots at 90 km

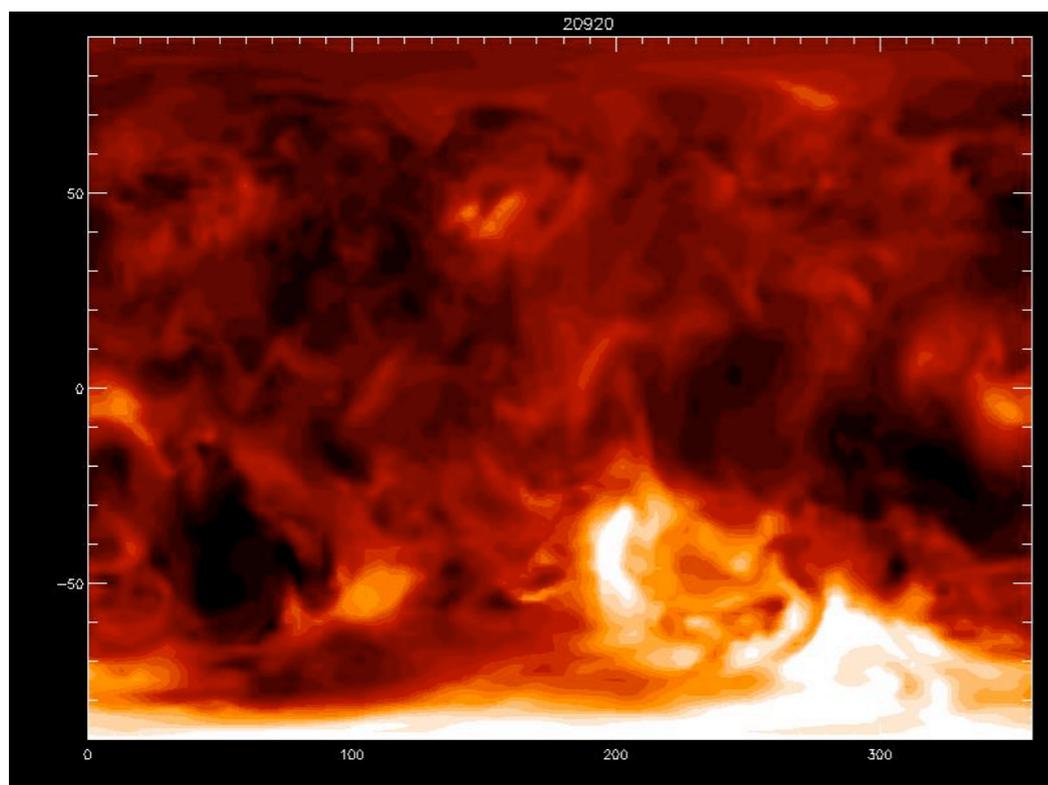
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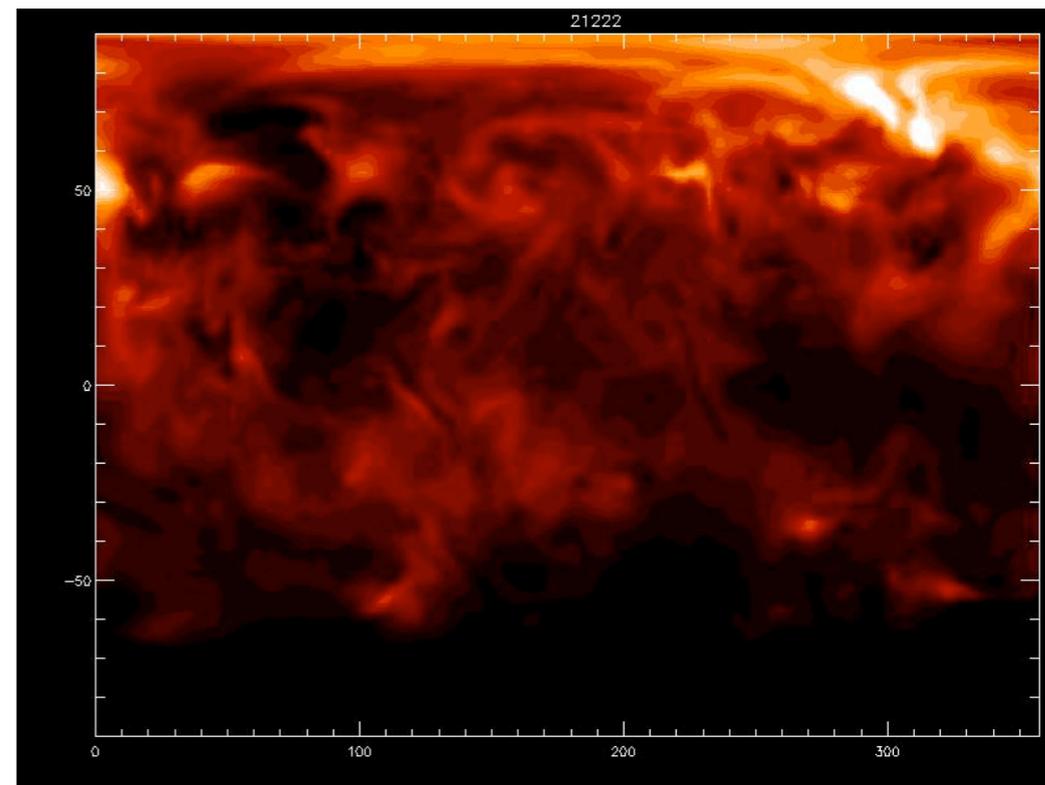
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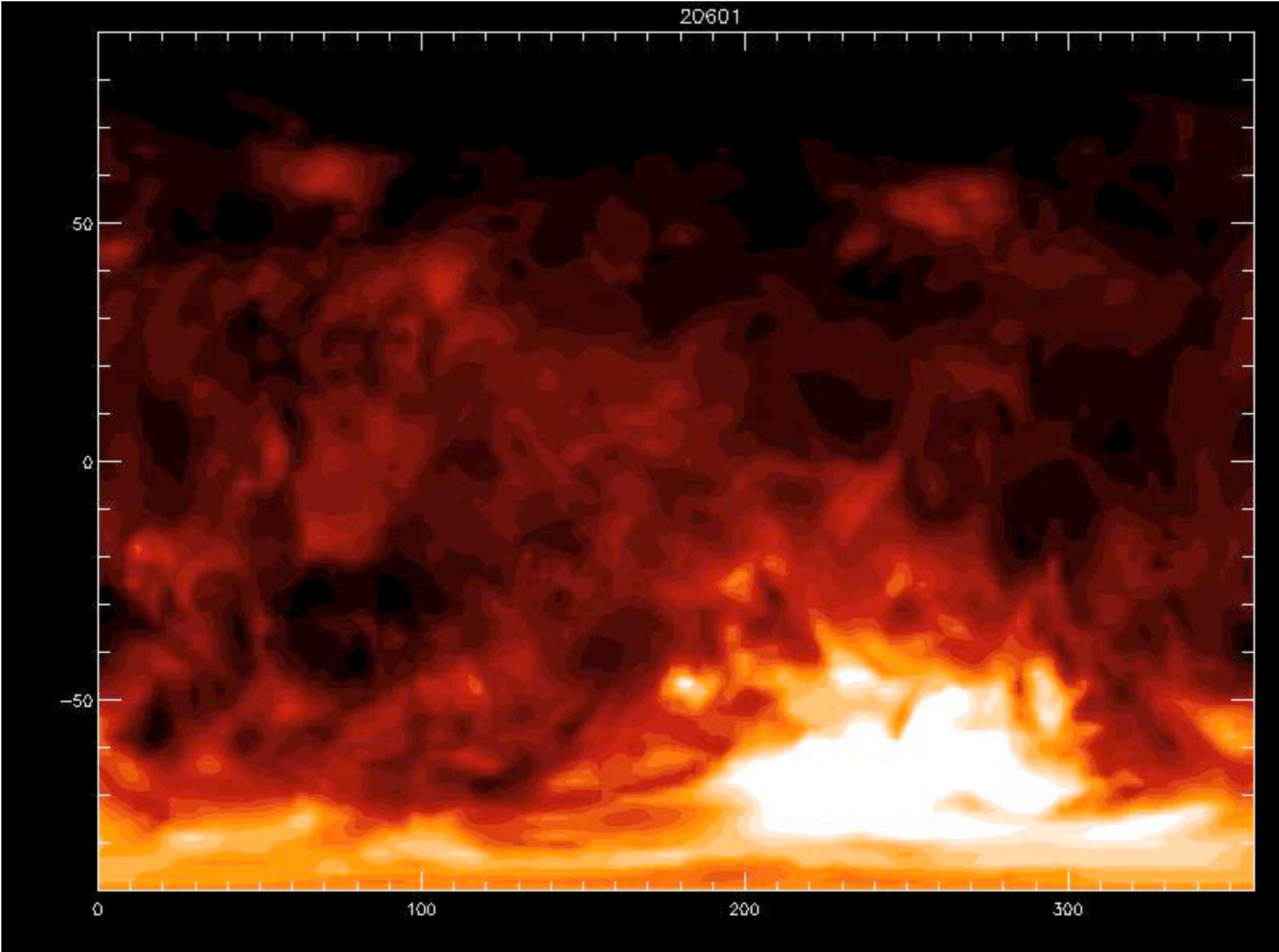




Daily 'snapshots' of sodium ~90km / UT00



Daily 'snapshots' of sodium ~90km / UT00





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Summary

- First global Na model with self-consistent ionosphere and realistic MIF
- Modeling of Na is a stringent test on the MIF, dynamics and chemistry of the MLT
- Seasonality well reproduced in the model
- Model can provide insight into what drives day-to-day variability seen by a single LIDAR facility
- Absolute densities higher than observed:
 - Only removal mechanism is the dimerization of sodium bicarbonate:
 $2\text{NaHCO}_3 (+M) \rightarrow (\text{NaHCO}_3)_2$
 - Missing Na removal on meteoric smoke and PMC particles
 - Compensated by 6 t/d MIF and PMCs are usually at lower altitudes



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Thank you



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