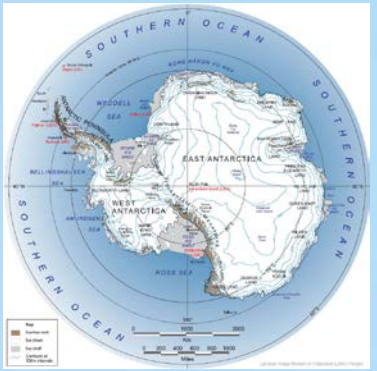
6th International GEOS-Chem Meeting
May 08 2013

# Investigating the Sources of Nitrate in Antarctica using GEOS-Chem and its Adjoint




[NSF-ANT 0944537]

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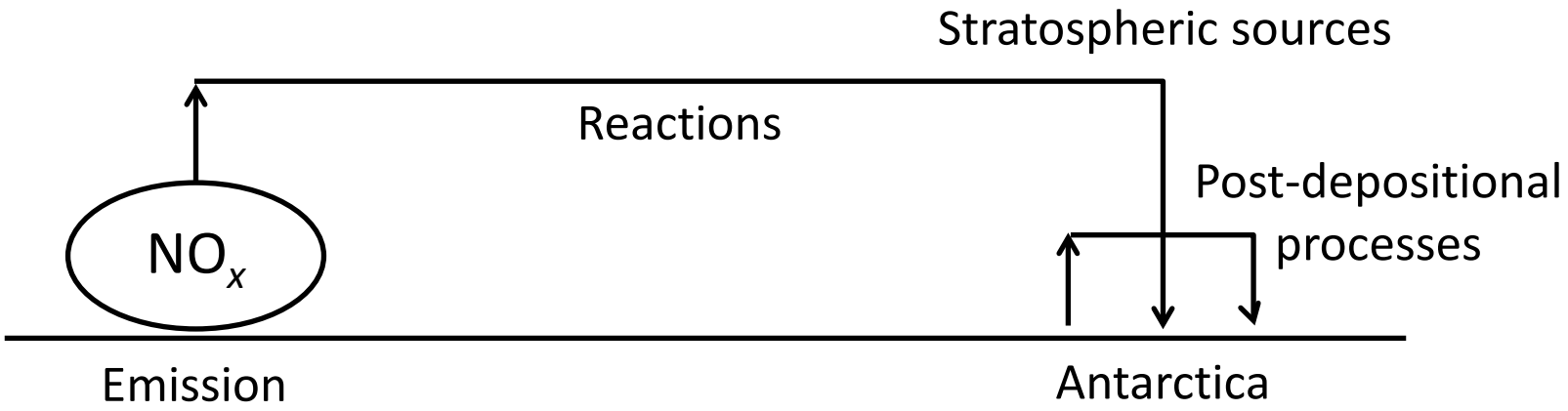
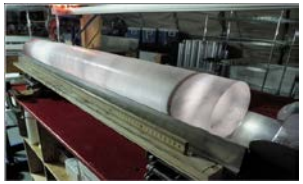
# I. Background

## Difficult to relate sources to measurements

## ( $NO_x \leftrightarrow HNO_3 + NO_3^-$ )




Anthropogenic, Biomass, Lightning, …
$SO_2$, $NH_3$, ISOP, …



## Suggested sources

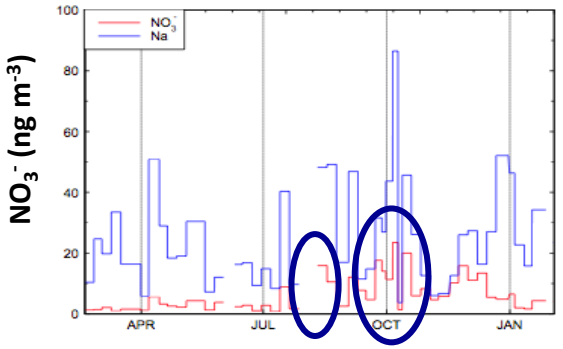
- **Long-range transport**
- Solar activity
- **Stratospheric influence (PSCs, air mix)**
- Post-depositional processes

# I. Background

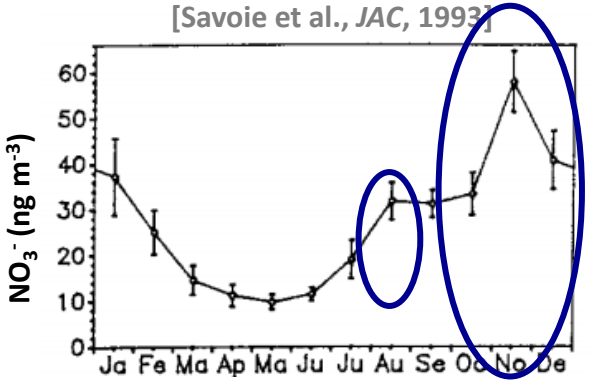
## Annual Variation from Measurements

## (1) August peak (2) Maximum in Summer (Nov-Jan)

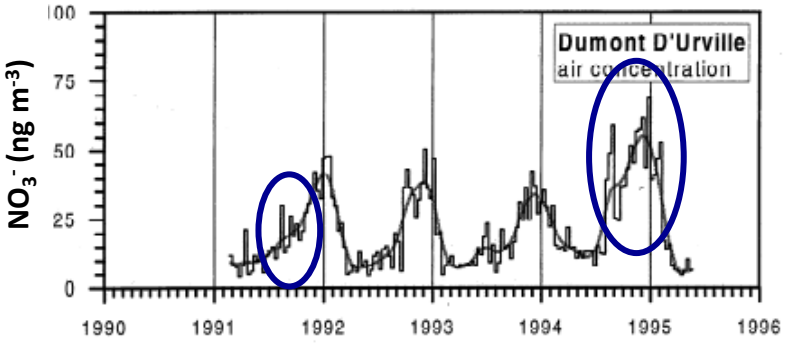
[Wolff et al., *ACP*, 2008]



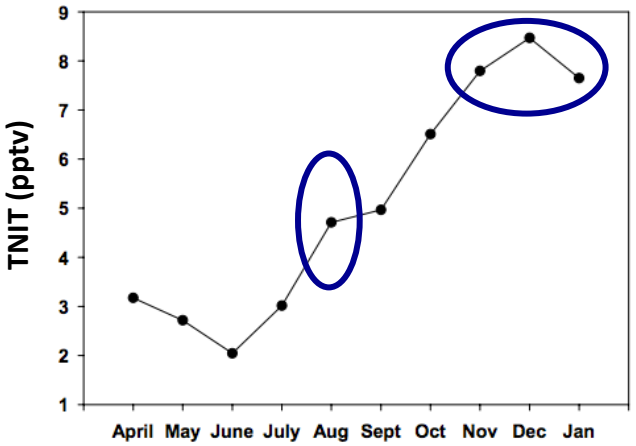

[Savoie et al., *JAC*, 1993]




[Wagenbach et al., *JGR*, 1998]




[Jones et al., *ACP*, 2008]



# II. Model Specification

## Version

Adj-33f (fwd 8-03-02)

## Resolution

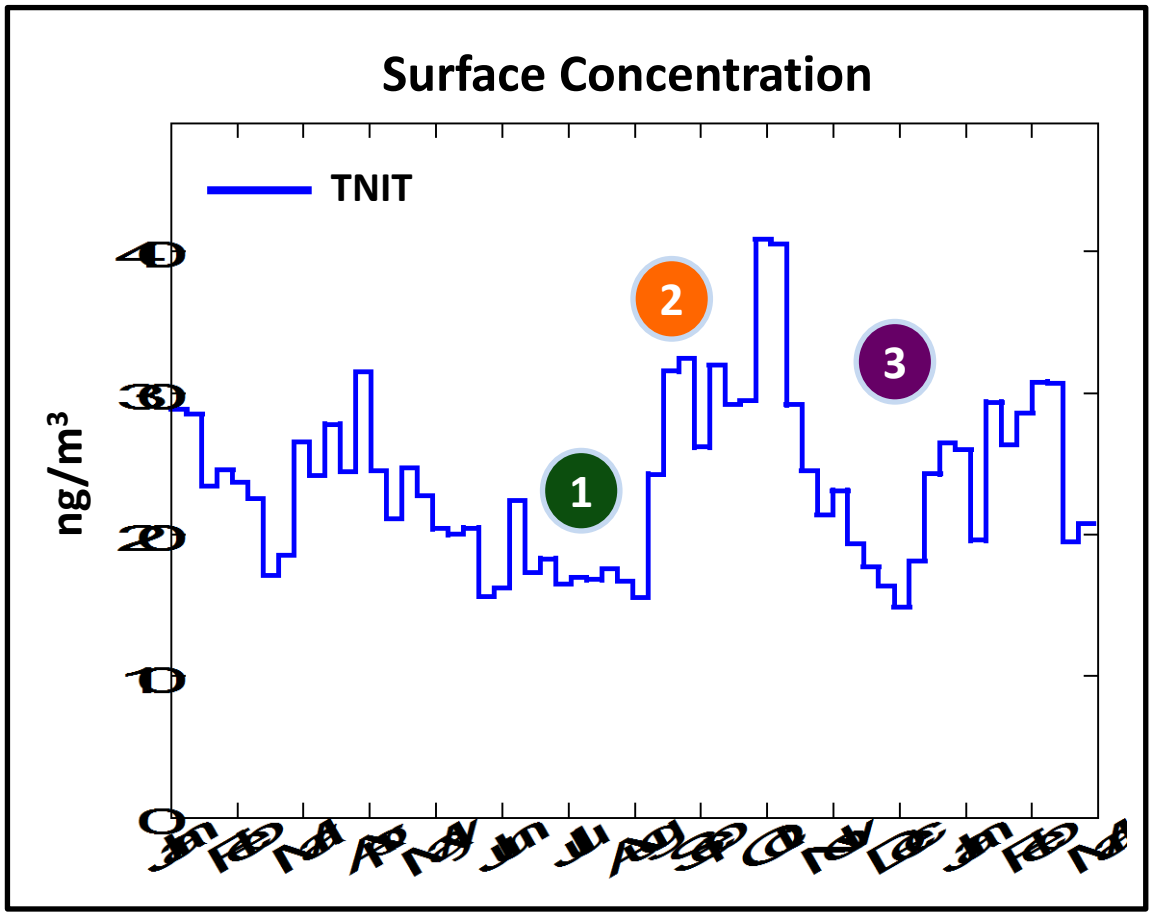
Reduced GEOS-5 (4° x 5° x 47)

## Modifications

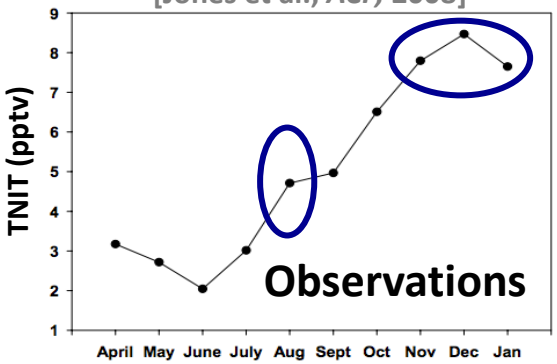
Stratospheric chemistry [Murray, 2012] and adjoint [New!]

Sensitivity w.r.t. reaction rates [Paulot, 2012] [Walker, 2012]

# III. Modeled Seasonality




[Jones et al., *ACP*, 2008]




**1** **Minimum: Acceptable**

**2** **August Peak: Needs enhancement**

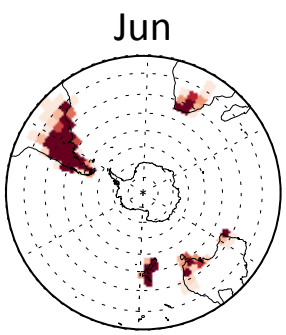
**3** **Maximum: Not captured**

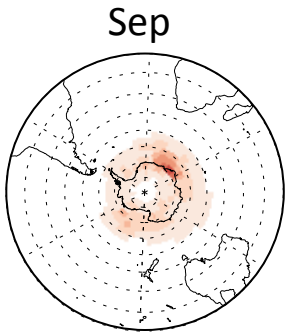
TNIT = $HNO_3$ + $NO_3^-$

# IV. Diagnosis with the Adjoint

**Major sources**

1. **Minimum: Acceptable**
   - Anthropogenic NO*x* **15%**
   - Soil NO*x* **7%**
   - Lighting NO*x* **4%**
2. **August Peak: Needs enhancement**
   - Stratospheric NO*x* **4%**
3. **Maximum: Not captured**
   - Stratospheric NO*x* **7%**
   - Stratospheric $HNO_3$ **6%**



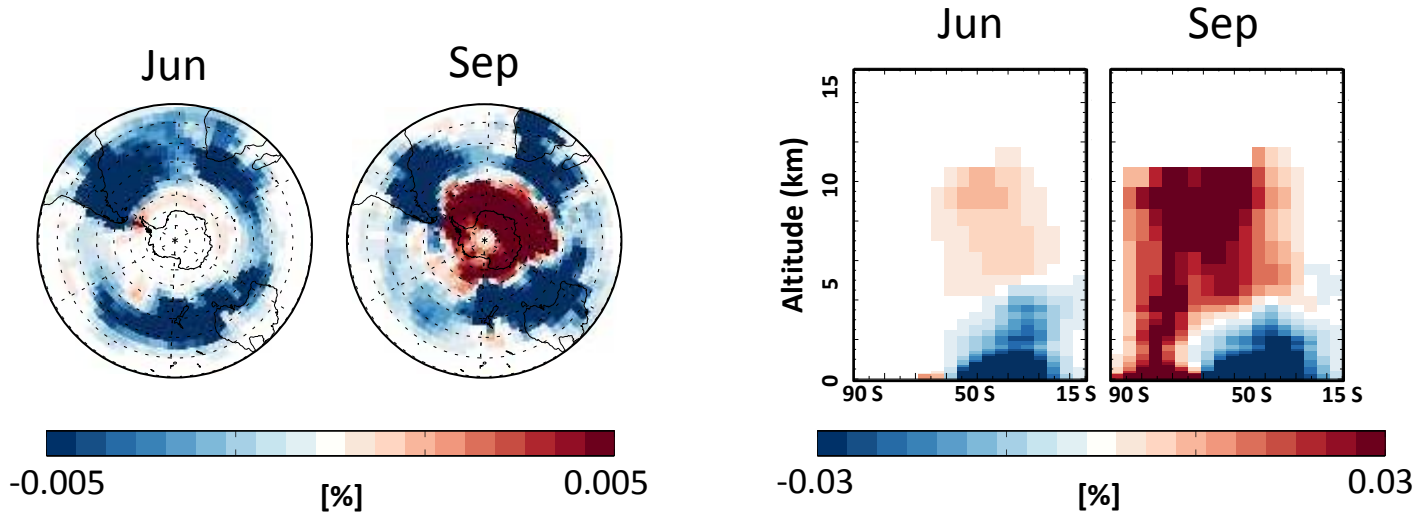




1

**Minimum: Acceptable**

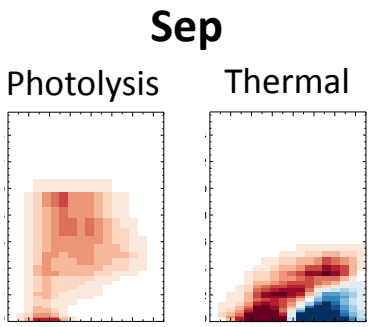
# Background concentration: Long-range transport

$NO_2 + OH \rightarrow HNO_3$




## $NO_2$ supply

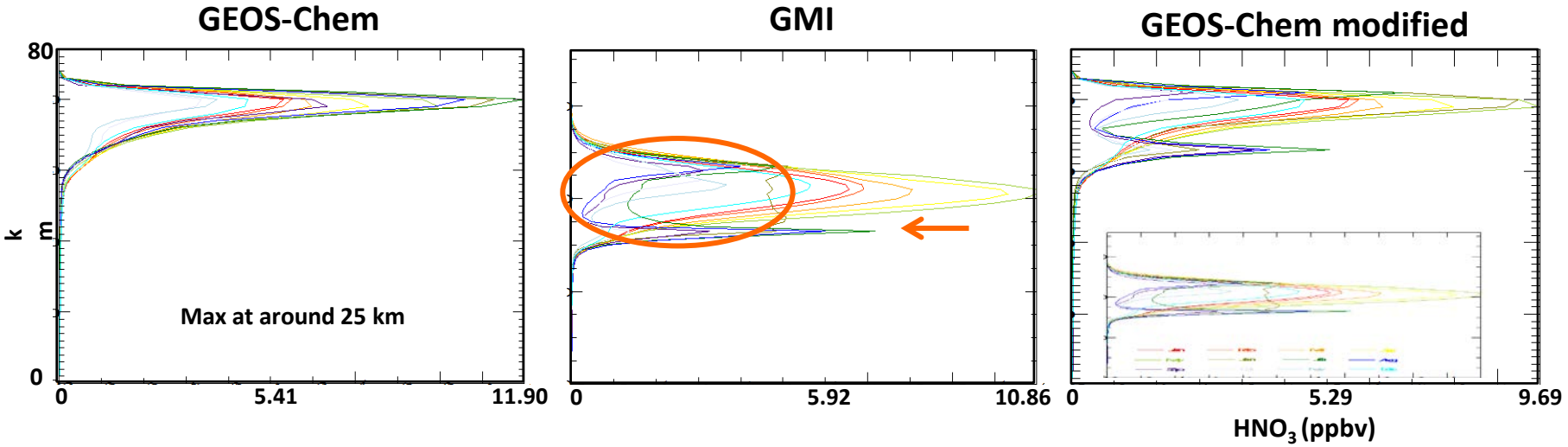
- PAN decomposition
- Emission
- Stratosphere

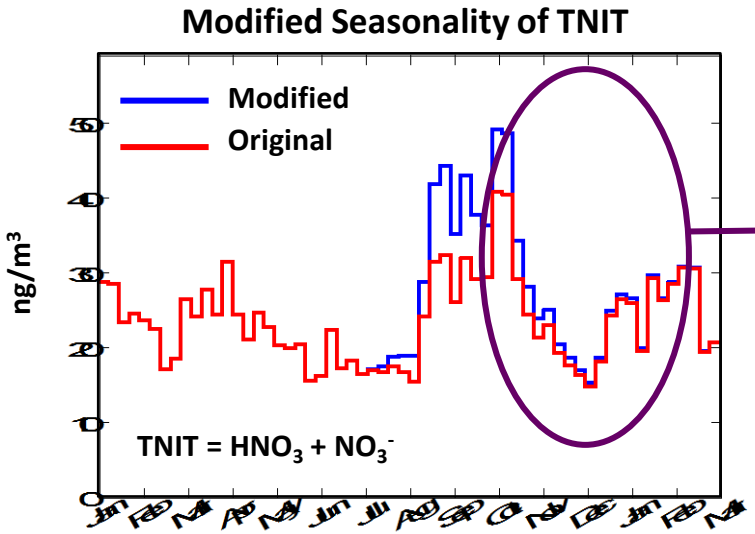


2

**August Peak:**
**Needs enhancement**

# Denitrification by PSC sedimentation
## (Polar Stratospheric Clouds)




3

**Maximum:**
**Not captured**

**Post-depositional processes**

# Conclusion

1. **Minimum: Acceptable** — **Long-range transport** from mid-latitude free troposphere

**For better understanding Antarctic Nitrate**

2. **August Peak: Needs enhancement** — **PSC sedimentation** [Considine et al., 2000] [Eastham et al., !]
3. **Maximum: Not captured** — **Post-depositional processes** [Zatko et al., 2012]
4. **$NO_3^-$: Small and off season** — **Aerosol thermodynamics** [Capps et al., 2012]