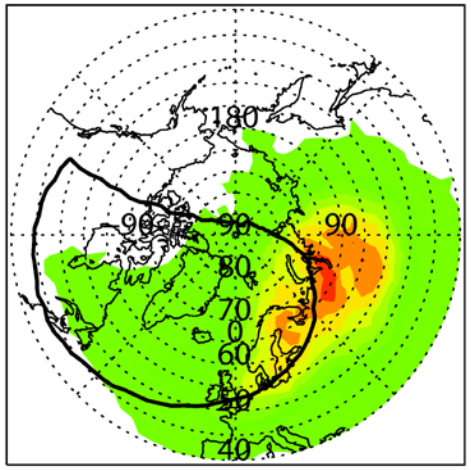
Observations and Modeling Climatology of Polar, Wintertime Middle Atmosphere Disturbances



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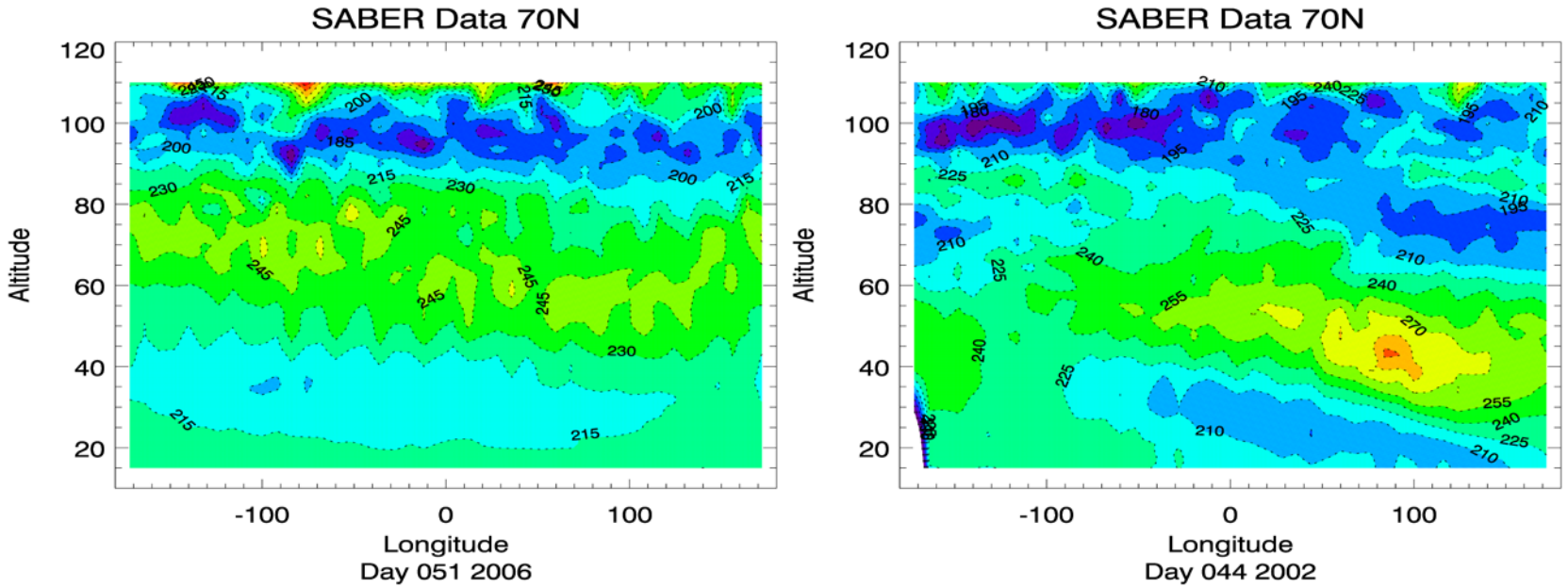
CESM Whole Atmosphere Working Group Meeting

Upper Stratosphere Lower Mesosphere (USLM) Disturbances



- **Strong baroclinic conditions near stratopause**
- **Elevated stratopause temperatures in excess of 290 K**
- **Stratopause located at 42 km +/- 2 km**
- **Strong positive temperature gradient below 40 km**
- **Concentrated latitudinal and longitudinal extent**
- **Rapid Development**

Data and Analysis Methods

Observations
- TIMED/SABER
- Lidar
- Rockets

} Limited

Assimilated Data: MetO
- October 1991 to 27 December 2010
- Once daily (12Z)
- Temperature, winds, and geopotential heights
- 2.5° latitude by 3.75° longitude
- 1000 to 0.3 hPa (0.1 hPa after late 2003) pressure surfaces

British Atmospheric Data Centre
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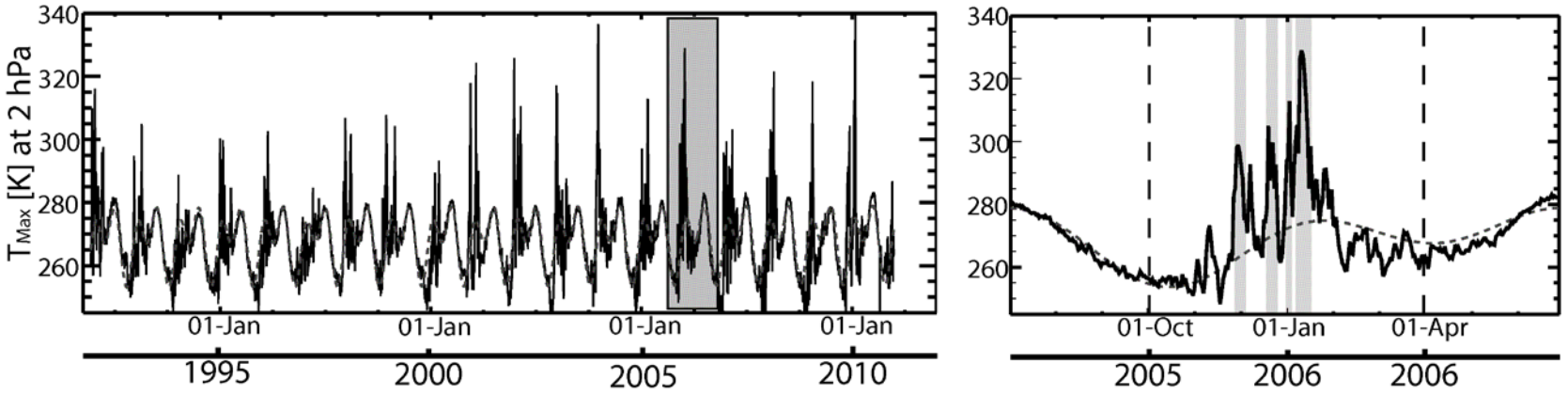
Model: WACCM4
- 42 year run; 2 year spin-up
- CESM framework
- Hybrid vertical scale: 66 levels
  - isobaric above ~100 hPa
  - vertical resolution increases from 1.75 km around 50 km to 3.5 km above ~65 km
- 1.9 degrees latitude by 2.5 degrees longitude
- MOZART3
- Year 2000 SST
- Orographic gravity waves parameterized based on *McFarlane* [1987]
- Solar Max conditions

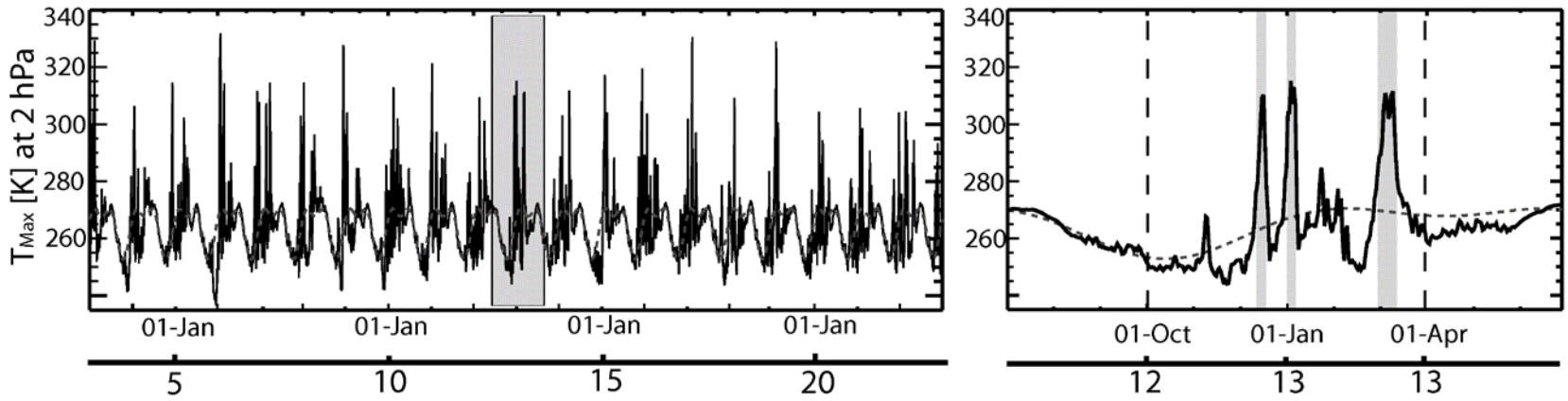
USLM Criteria and Event Identification

- Search for maximum temperature at 2.0 hPa between 40° and Pole
- Fit season function with annual and semi-annual variation
- Examine periods of significant temperature excursion from function >15K

(a) MetO Time Series



(b) WACCM4 Time Series



Validity and Logic of 2.0 hPa (42 km) Criteria Level

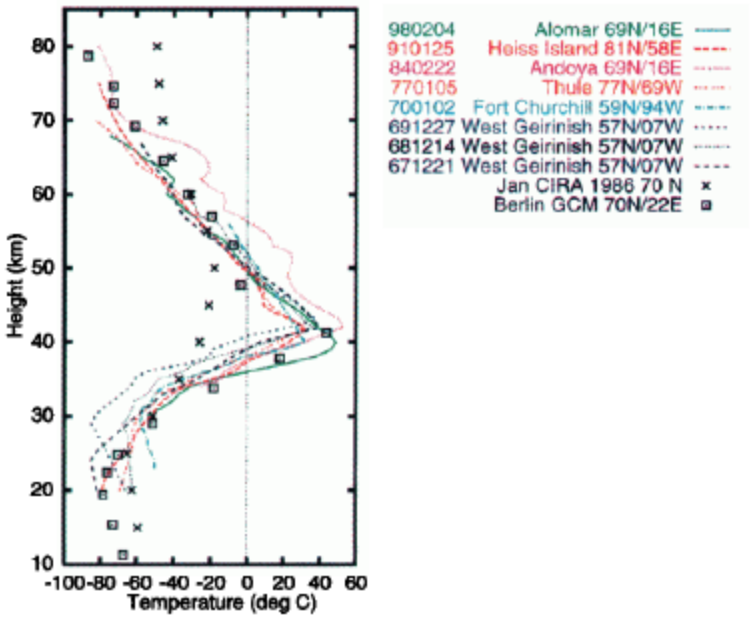


Figure 4. Vertical temperature profiles [°C] from several northern hemisphere rocket and lidar stations on the climax of different stratospheric warming events; crosses indicate the CIRA 1986 mean January profile at 70°N; sqares denote a profile from the Berlin TSM GCM

Von Zahn [1998]

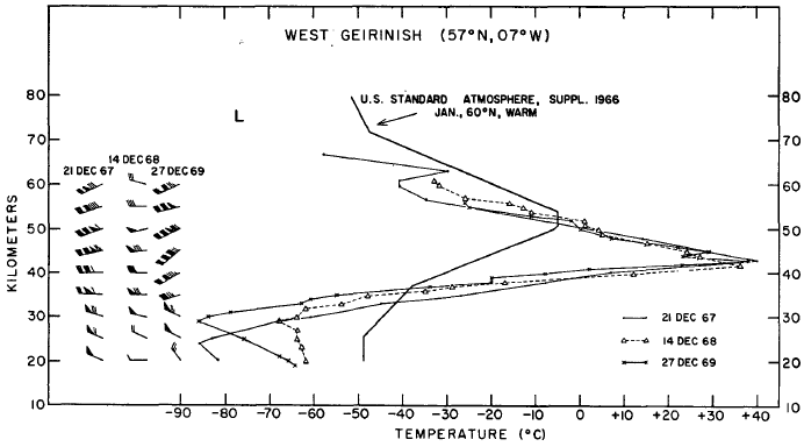
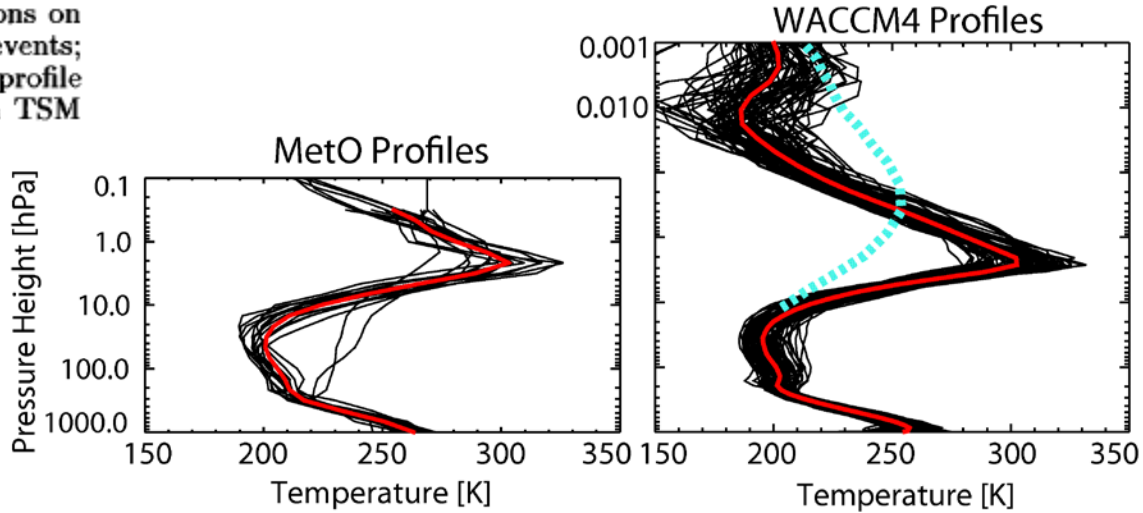


FIG. 5. Three profiles of rocketsonde data at West Geirinish and the U. S. Standard for January at 60N (warm).

Labitzke [1972]



Results of Search for USLM and SSW events in MetO and WACCM

MetO Data Set

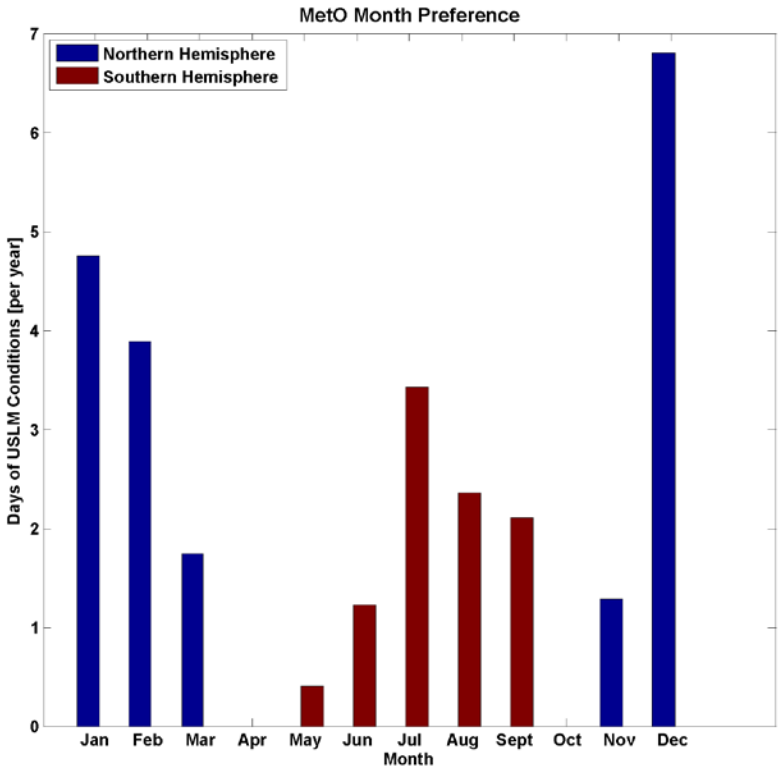
- 19.545 years long
- **NH**
  - 44 total USLM events
    - 2.25 USLM events/year
  - 18 total SSW events
    - 0.921 SSW events/year
- **SH**
  - 30 total USLM events
    - 1.535 USLM events/year
  - 1 SSW event

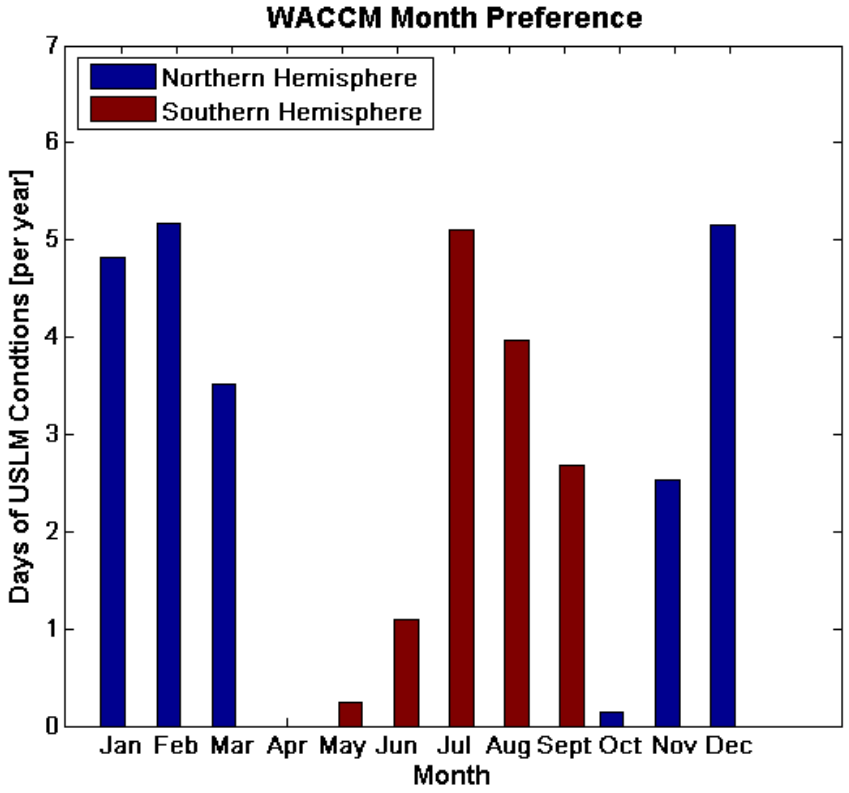
WACCM Data Set

- 40.0 years long
- **NH**
  - 118 total USLM events
    - 2.95 USLM events/year
  - 27 total SSW events
    - 0.67 SSW events/year
- **SH**
  - 89 total USLM events
    - 2.225 USLM events/year
  - 0 SSW events

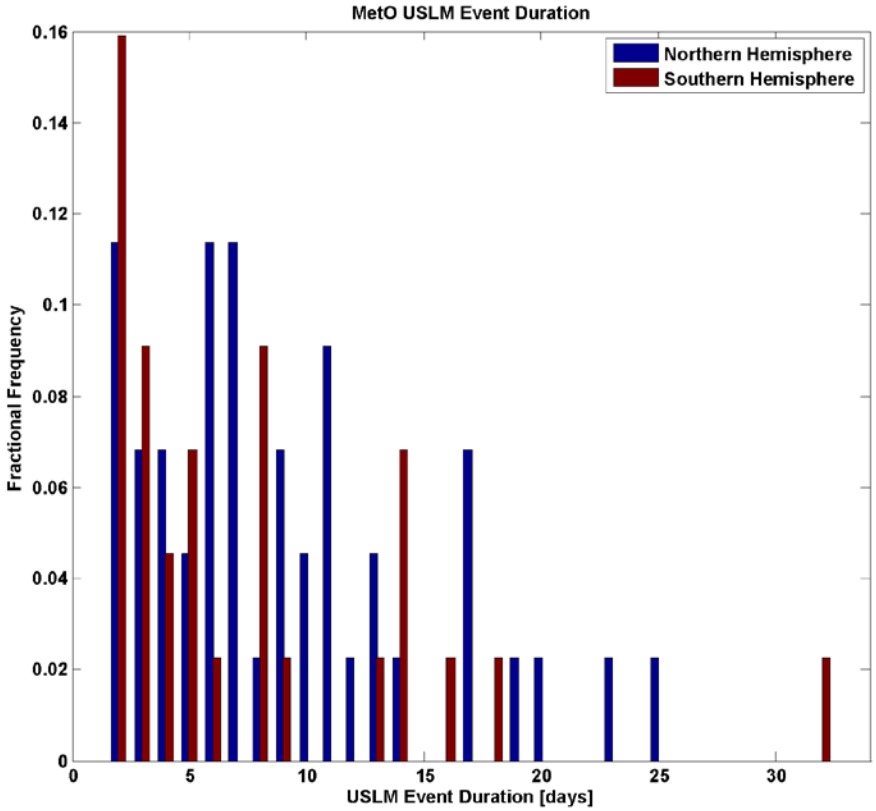
Dates of USLM event onset 1991-current available for those interested

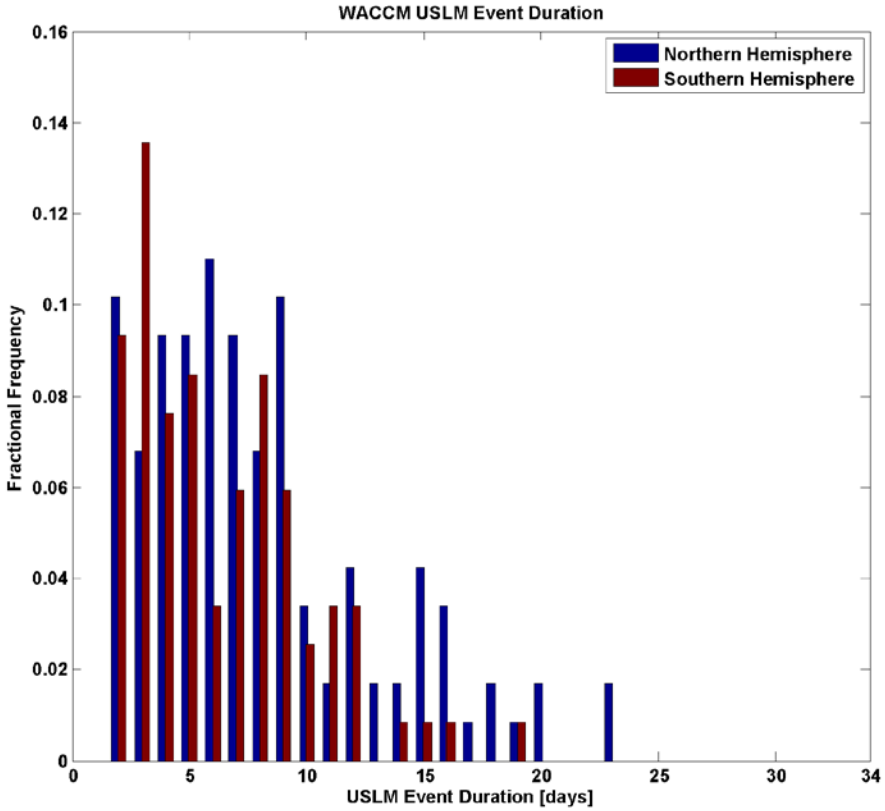
Distribution of USLM conditions throughout the year



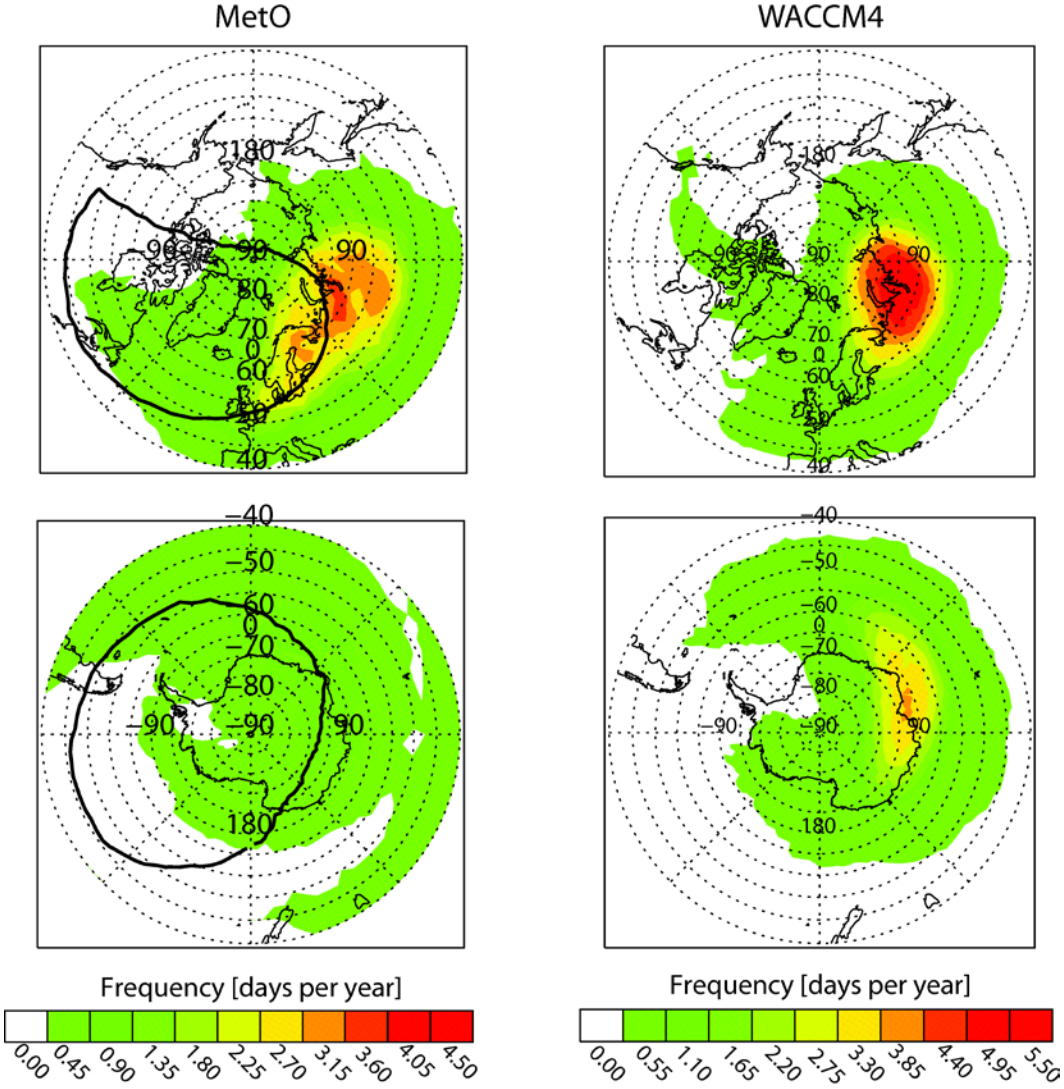


USLM Event Duration

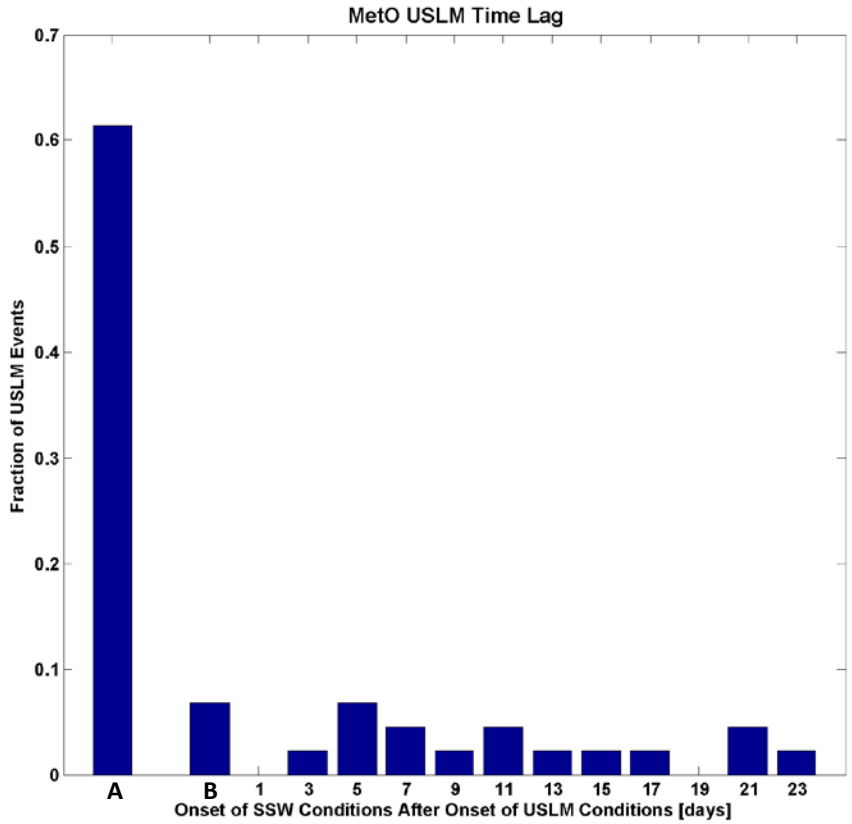


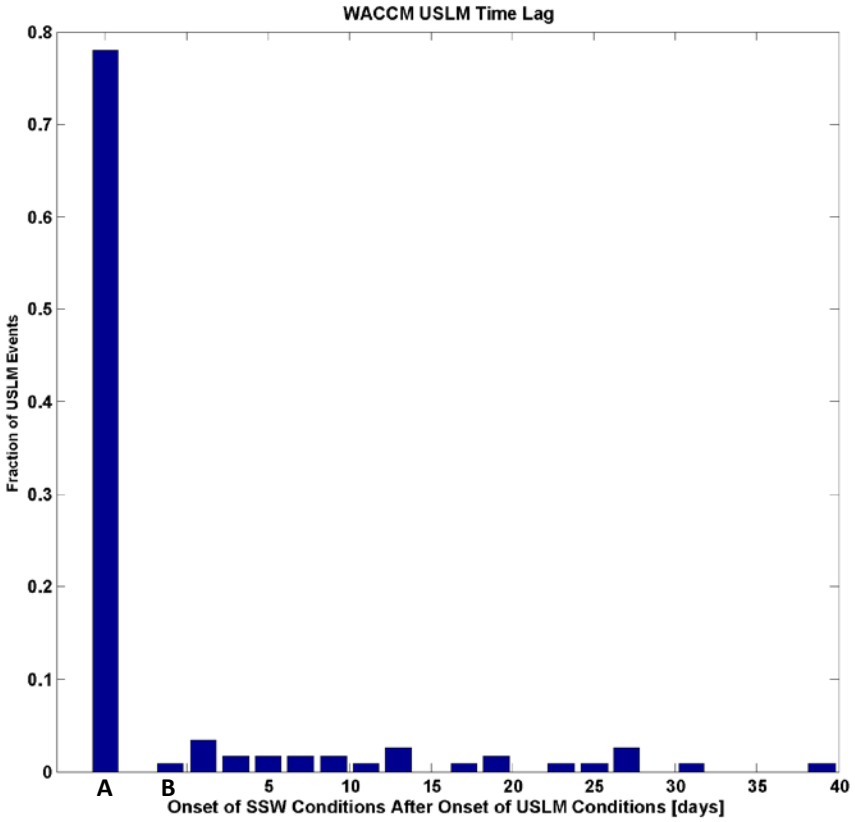


Geographical Preference of T anomaly & relationship with Polar Vortex



USLM disturbances relationship with development of major SSW





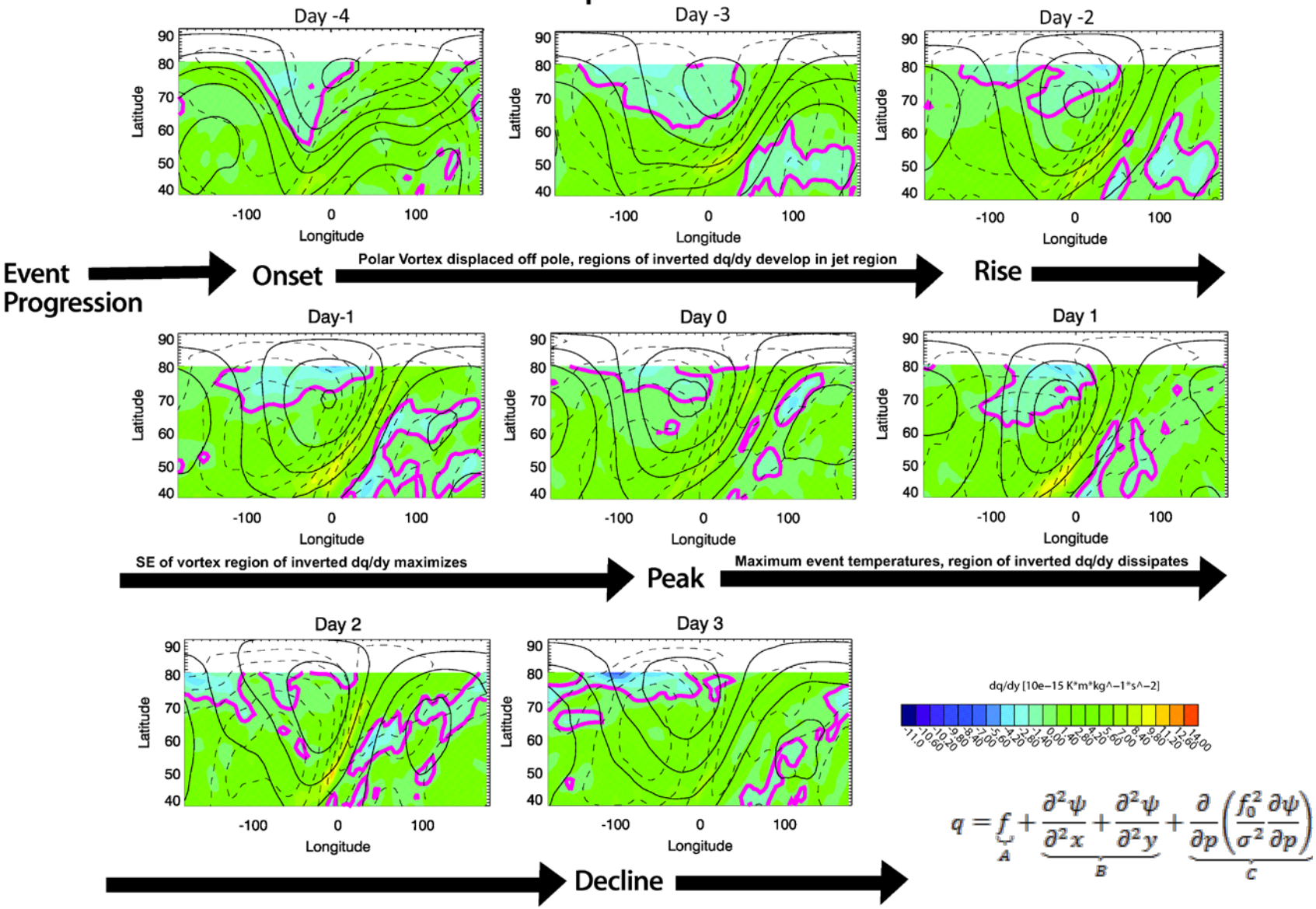
MetO and WACCM histograms of lag between USLM event onset and major SSW conditions onset. **A** events are USLM events that dissipated without a subsequent SSW event, **B** events are major SSW events that were final warmings.

Discussion

- Future WACCM explorations of USLM Disturbances
  - Baroclinic Instability Analysis
  - Planetary Wave Activity in development of USLM
  - Ageostrophic Circulations
  - Energy Transfers
  - Other Ideas?
- Use of TIME-GCM
  - Planetary wave forcing
  - In-situ generation of gravity waves?
  - Poor performance at low Stratopause level
- What attributes of the models might benefit this study?

Questions, Ideas, Suggestions?

Northern Hemisphere 2.154 hPa Pressure Surface



$$q = \underbrace{f}_{A} + \underbrace{\frac{\partial^2 \psi}{\partial^2 x} + \frac{\partial^2 \psi}{\partial^2 y}}_{B} + \underbrace{\frac{\partial}{\partial p}\left(\frac{f_0^2}{\sigma^2}\frac{\partial \psi}{\partial p}\right)}_{C}$$