MOD 5:
STE in mid-latitudes: climatologies and processes

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Outline

Concepts: transport - exchange - mixing

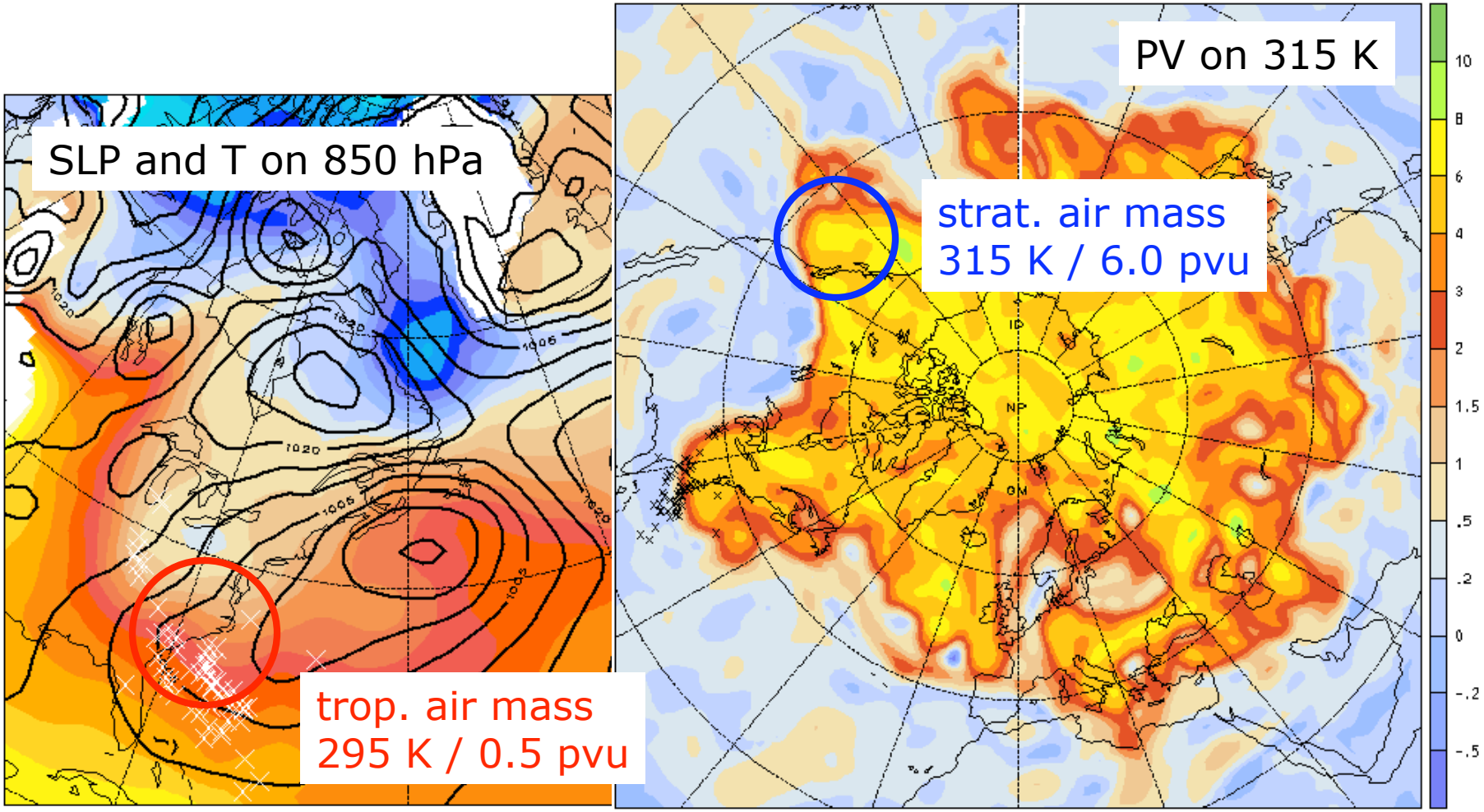
Climatologies of STE

(mainly northern hemisphere extratropics)

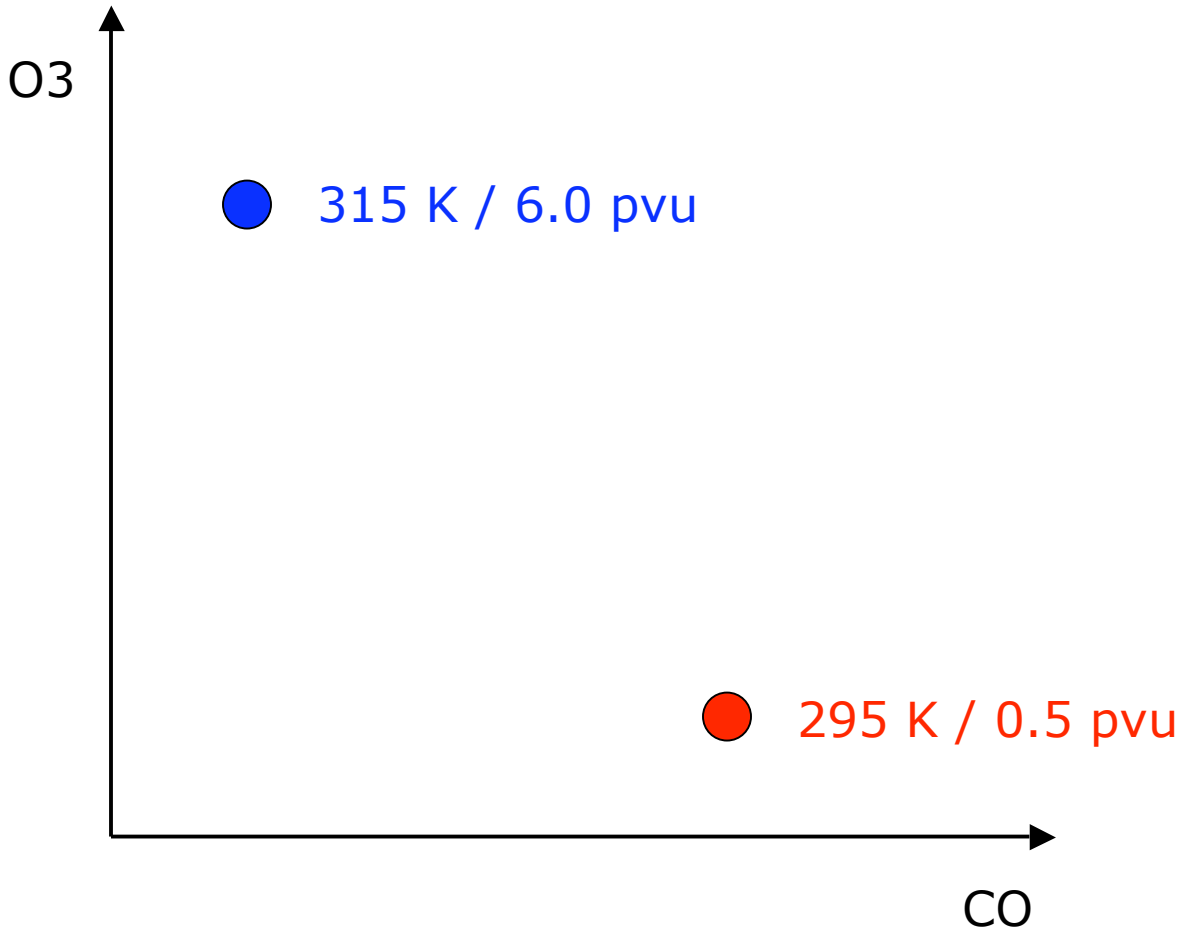
STE processes

- meteorological phenomena
- physical processes

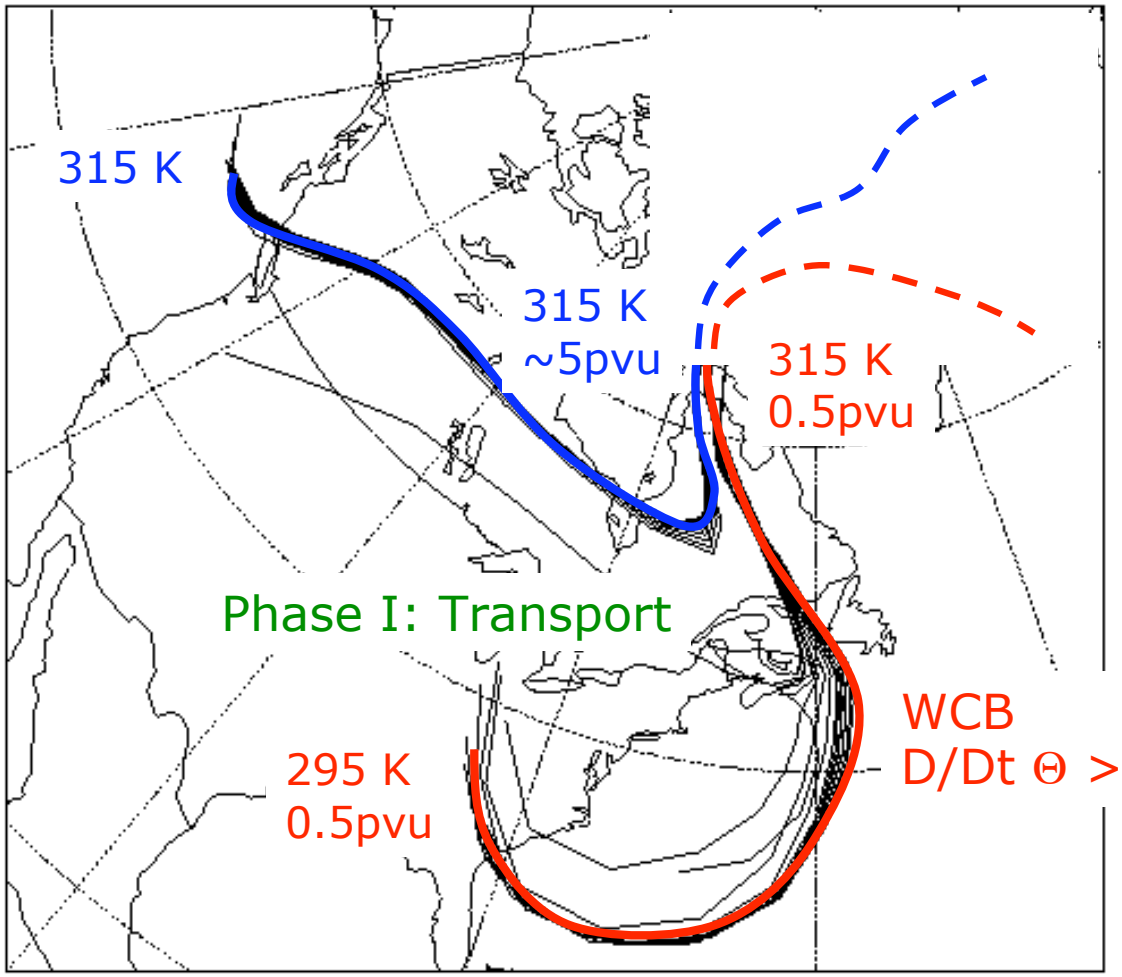
Transport - Exchange - Mixing



Schematic tracer-tracer correlation plot



Transport - Exchange - Mixing



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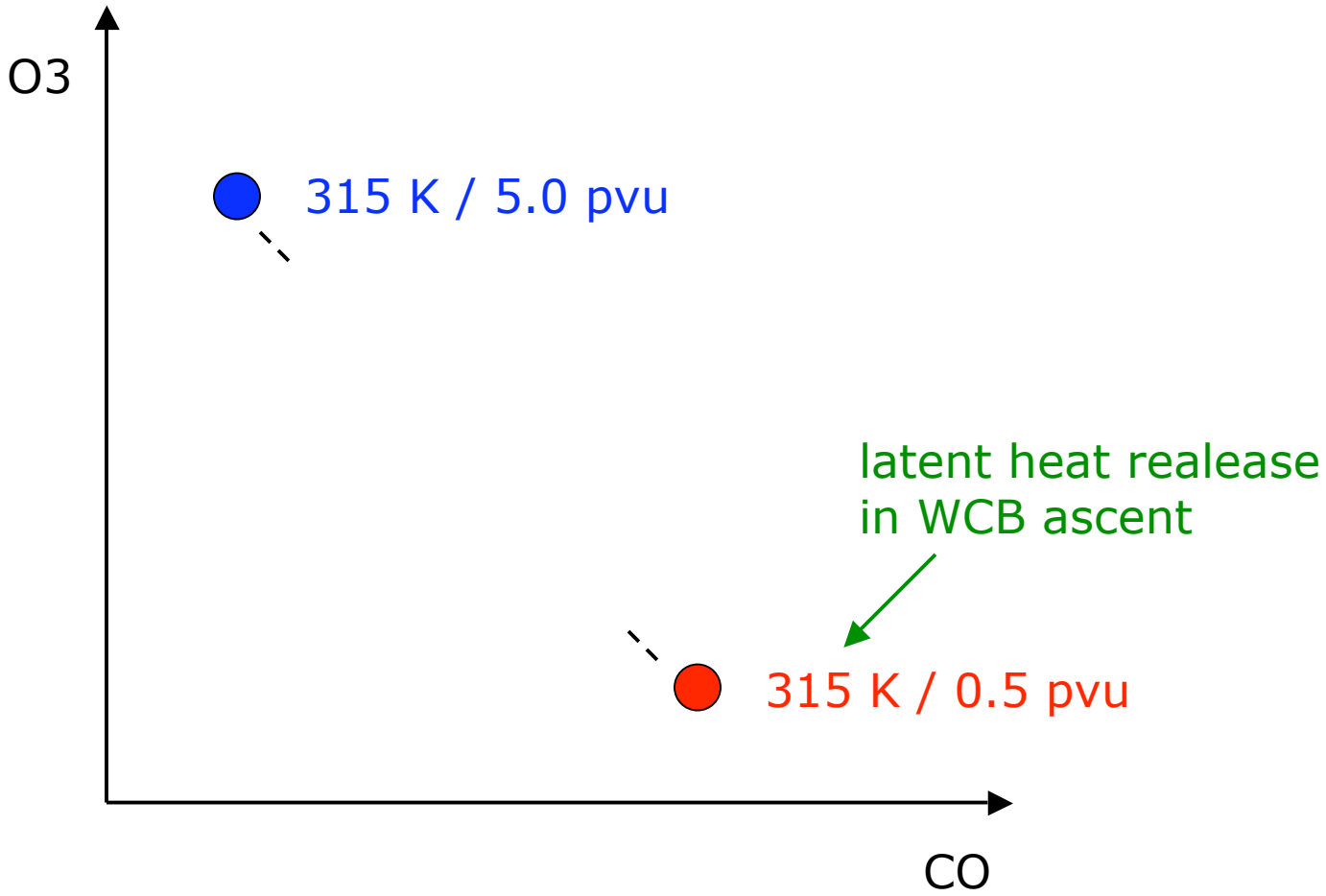
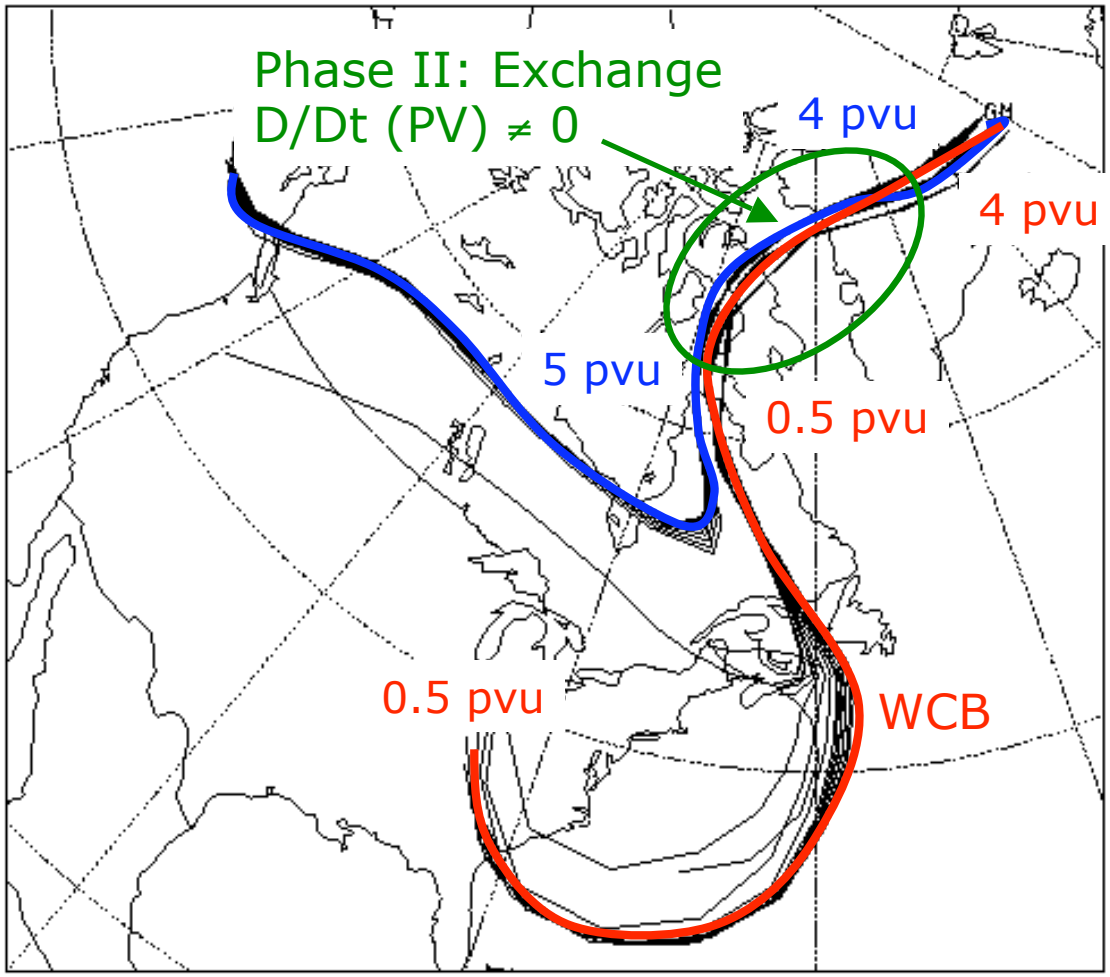
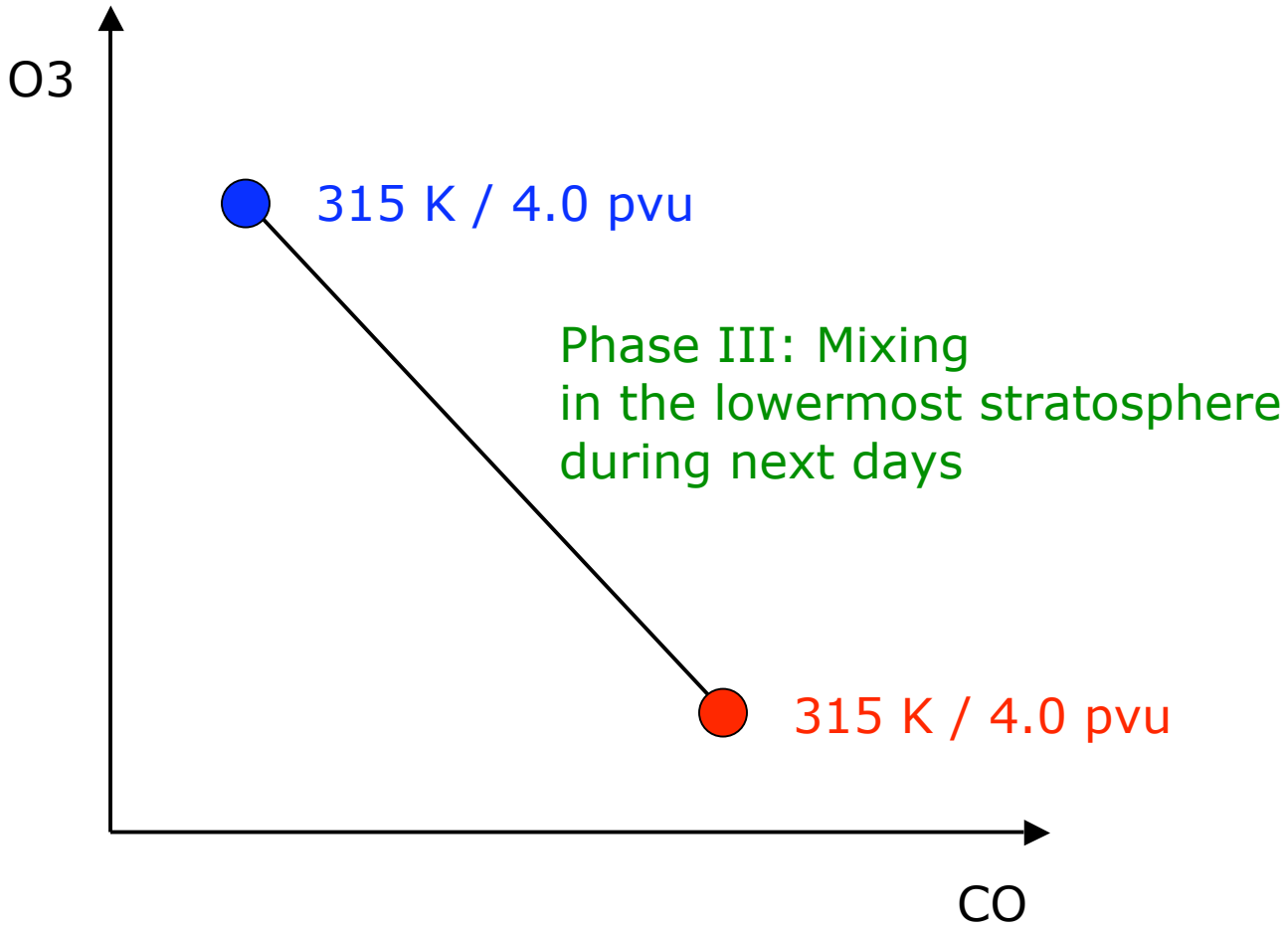


Transport - Exchange - Mixing



Schematic tracer-tracer correlation plot



STE climatologies

Geographical distribution of STT, TST, net fluxes

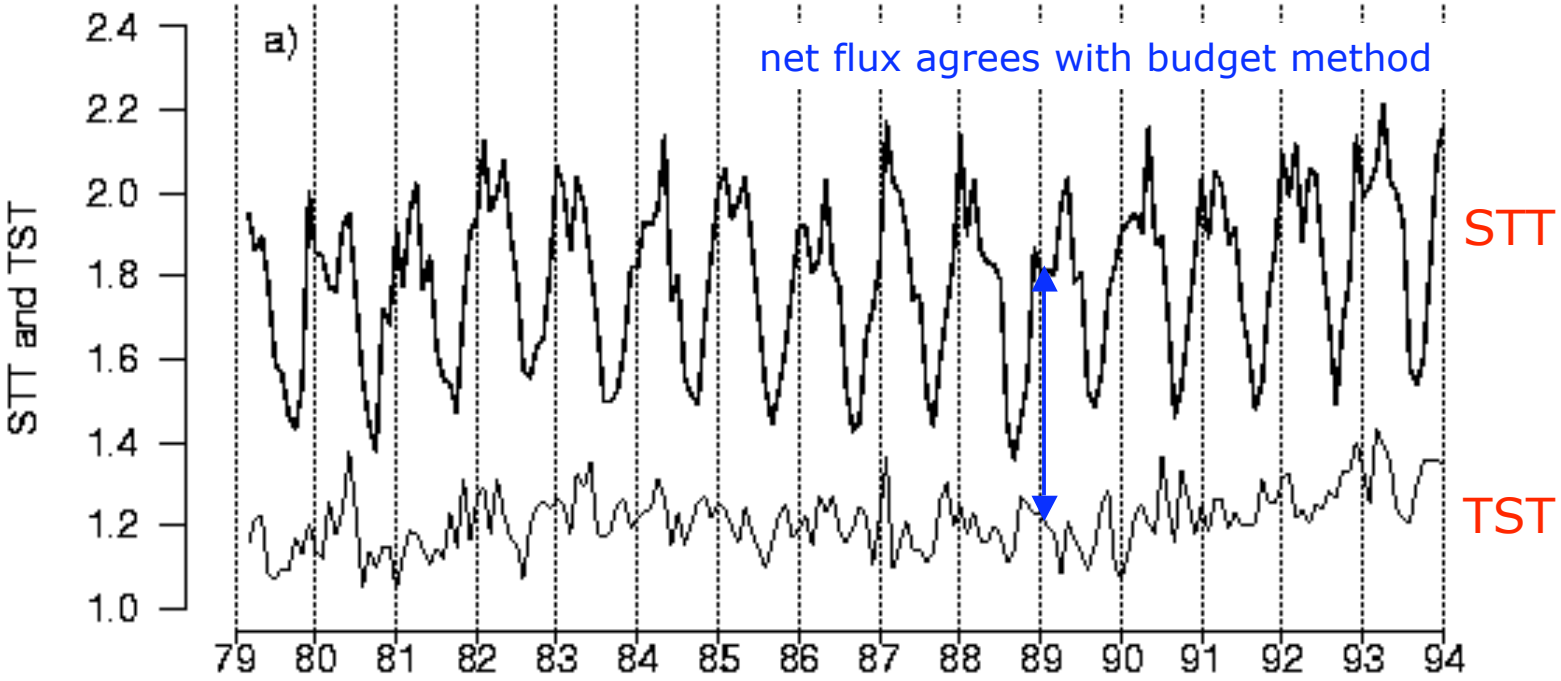
Seasonal differences

Interannual variation, trends

Deep exchange (transport between PBL and LS)

ERA15 climatology

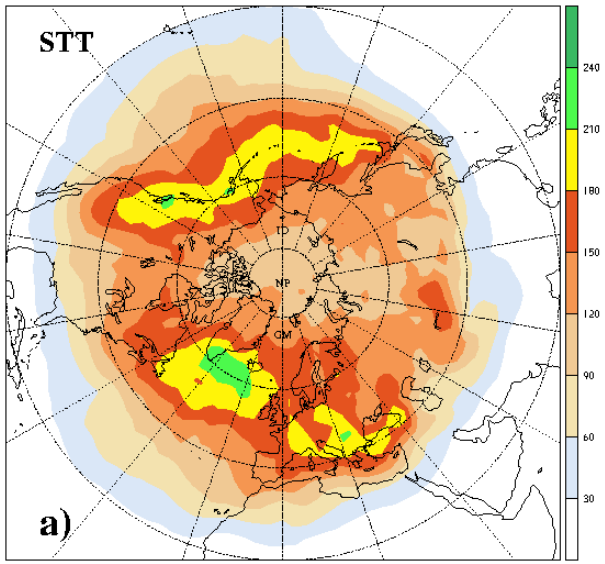
STT and TST mass flux (integrated for 20-90N)



Sprenger and Wernli 2003 (JGR)

ERA15 climatology

Annual mean geographical distribution of mass fluxes

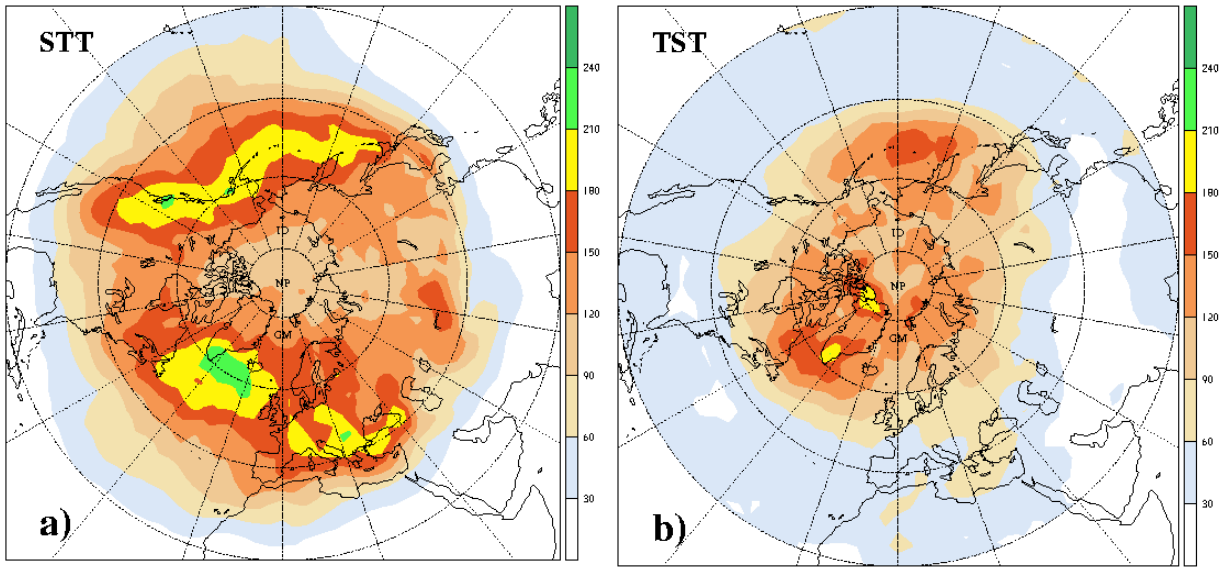


STT: large zonal variability
maxima near centre and end of storm-tracks

Sprenger and Wernli 2003 (JGR)

ERA15 climatology

Annual mean geographical distribution of mass fluxes

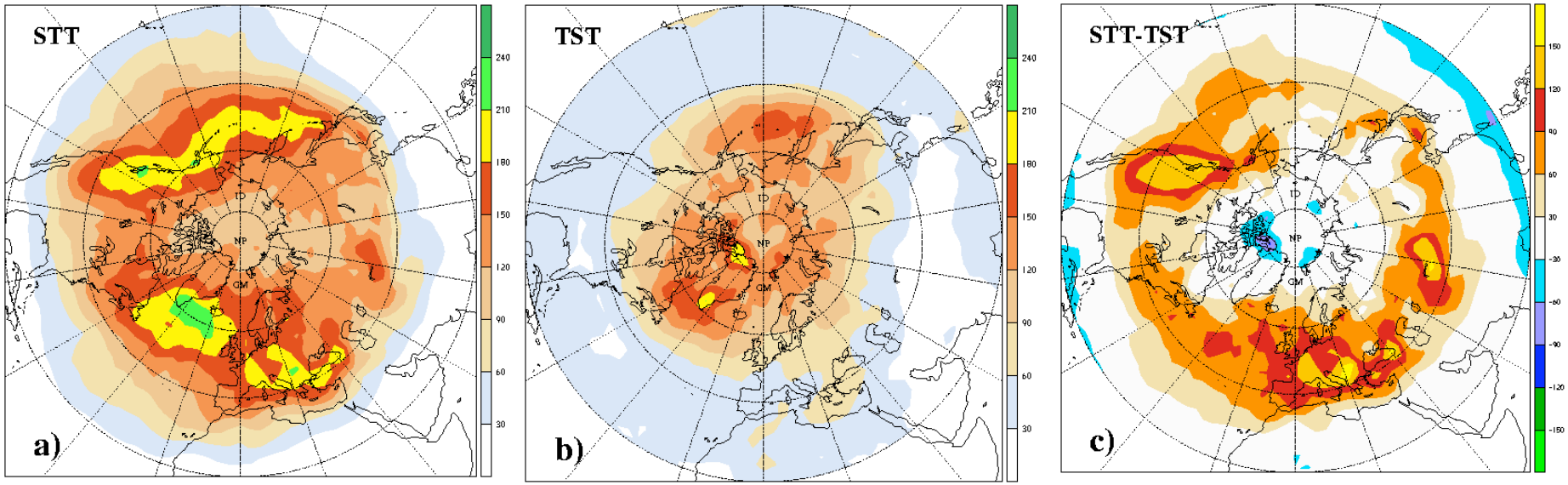


TST: less zonal variability
maxima near Greenland and Aleuten

Sprenger and Wernli 2003 (JGR)

ERA15 climatology

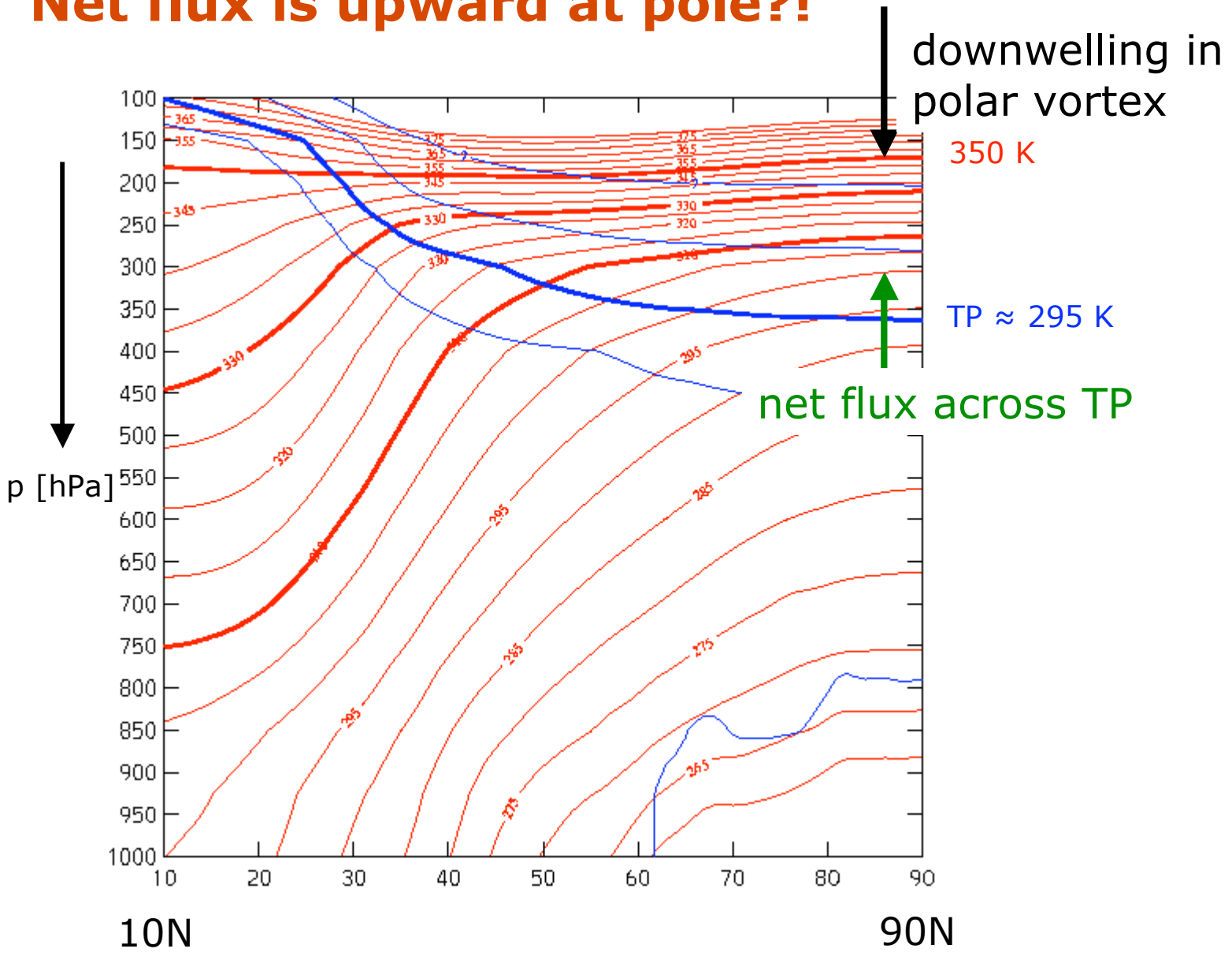
Annual mean geographical distribution of mass fluxes



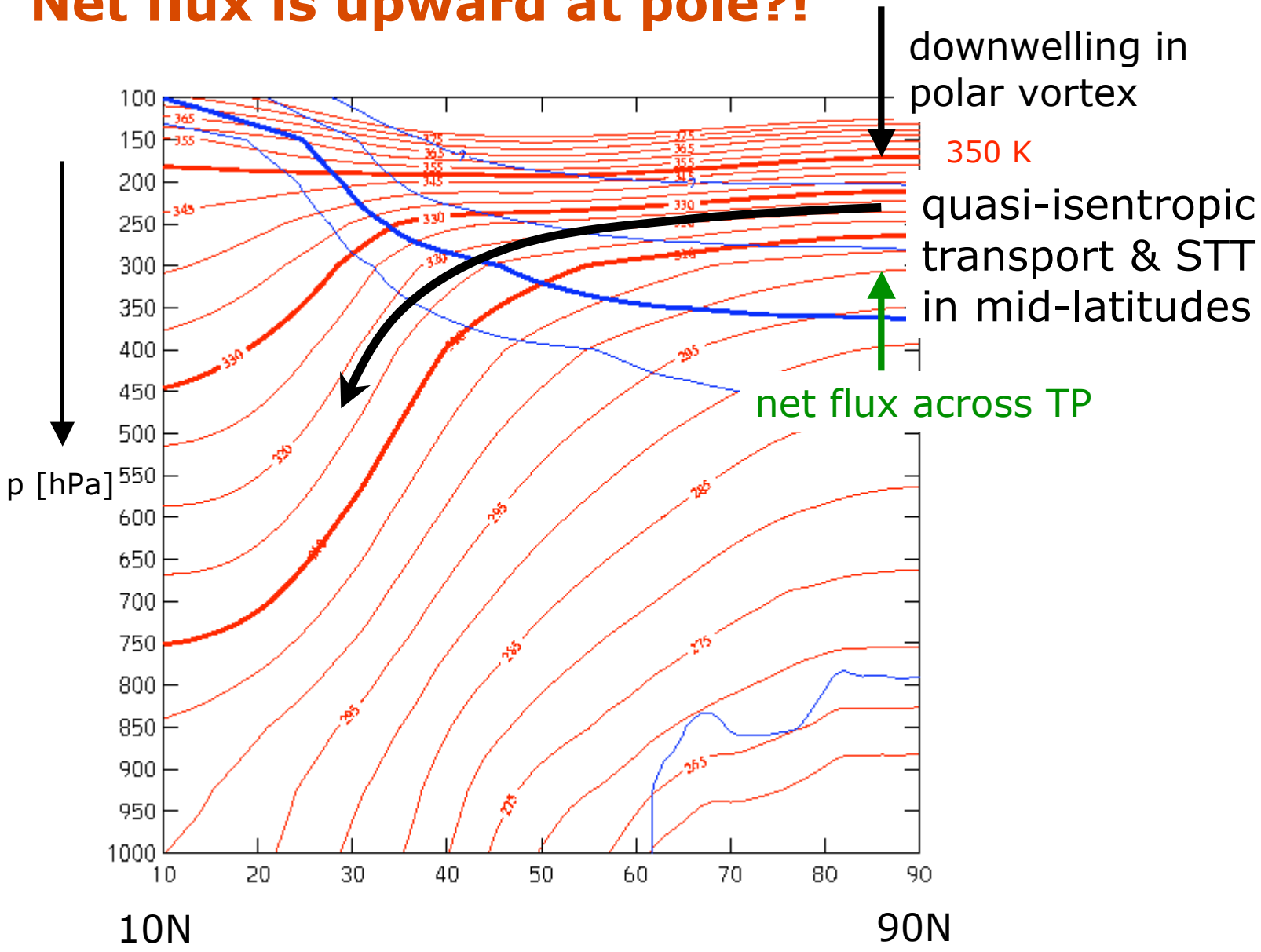
Net (STT-TST): pos. in mid-latitudes
weakly neg. in Arctic / subtropics
maxima towards end of storm-tracks

Sprenger and Wernli 2003 (JGR)

Net flux is upward at pole?!

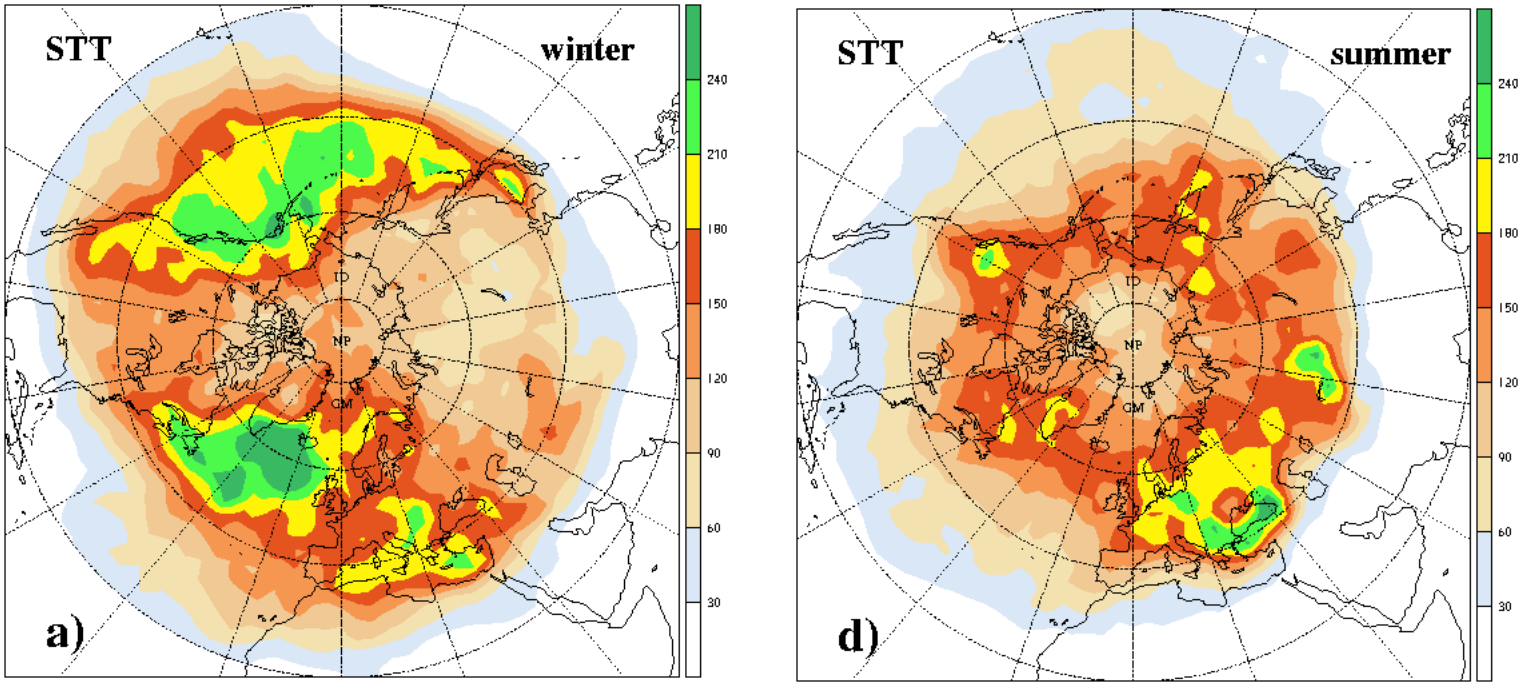


Net flux is upward at pole?!



STT: seasonal differences

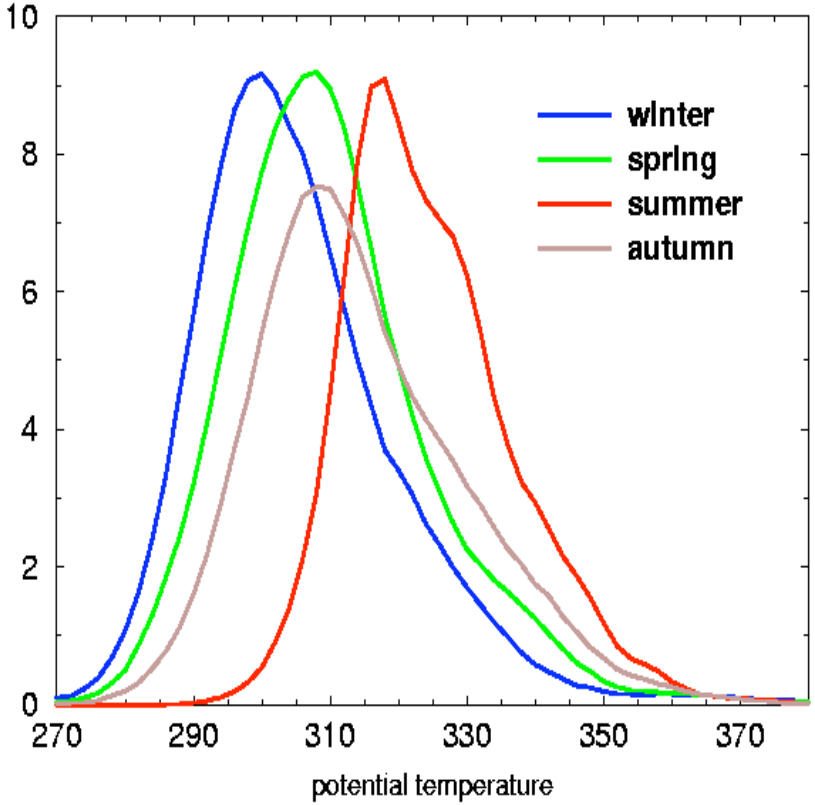
Winter vs. summer



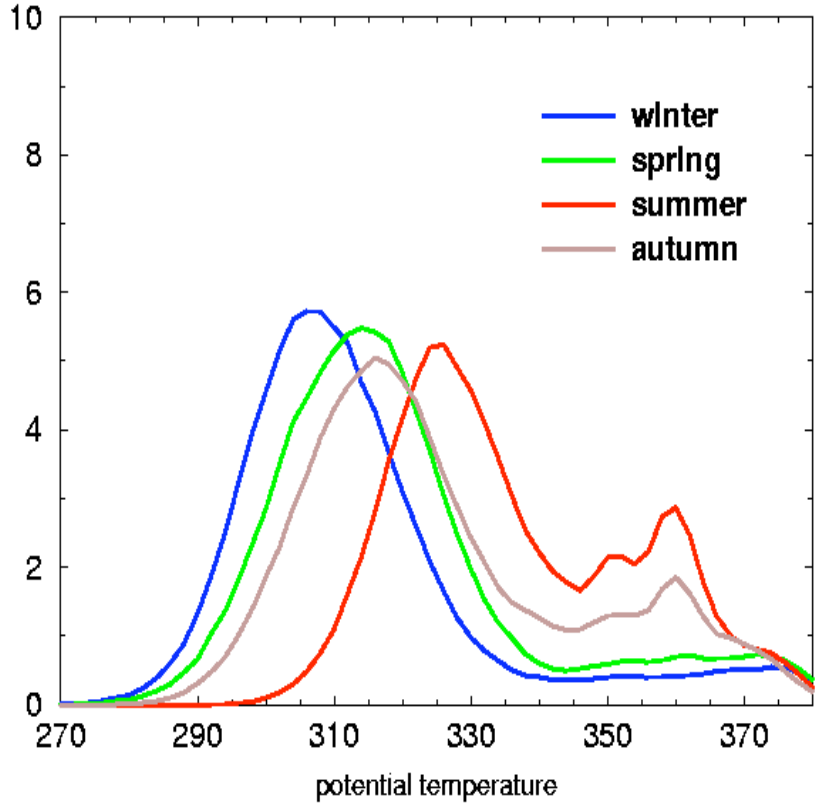
Sprenger and Wernli 2003 (JGR)

ERA15 climatology: Θ-distribution

STT



TST



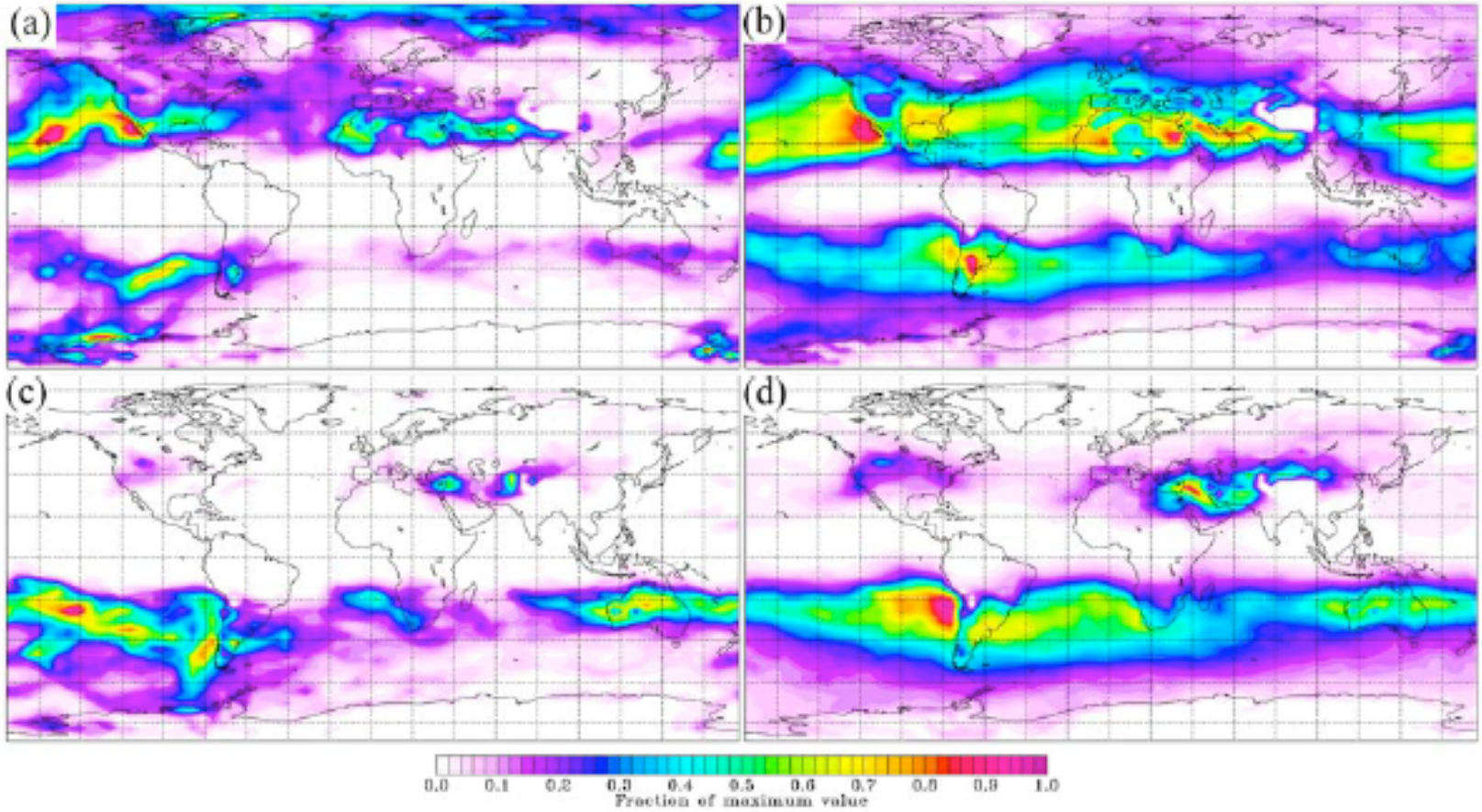
Sprenger and Wernli 2003 (JGR)

STT into PBL (< 3 km asl)

strat. tracer with age < 4 days <10 days

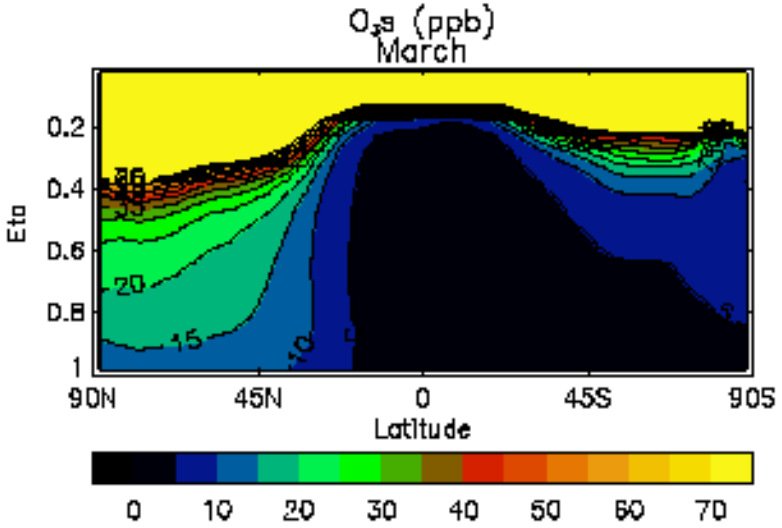
DJF

JJA

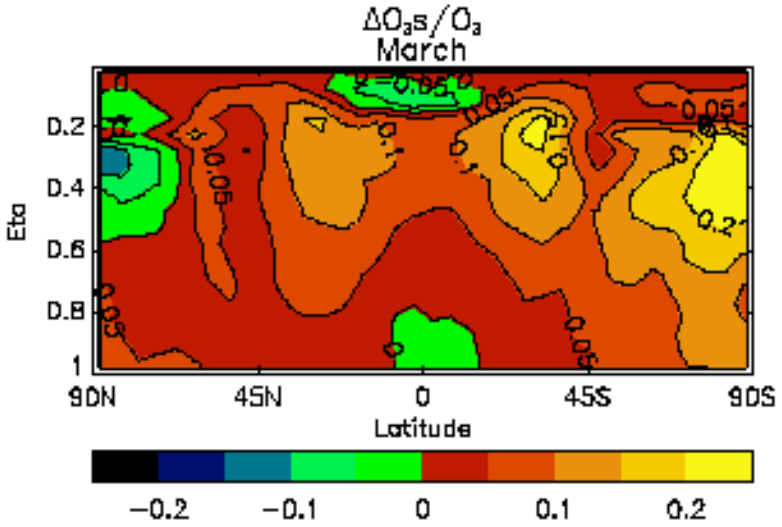


James et al. 2003 (JGR)

STT in future climate (2090 vs. 1990)



strat. ozone tracer
March 1990



relative change of strat. ozone tracer
→ 5-15% increase in most regions

Collins et al. 2003 (JGR)

STE and meteorological phenomena

For instance:

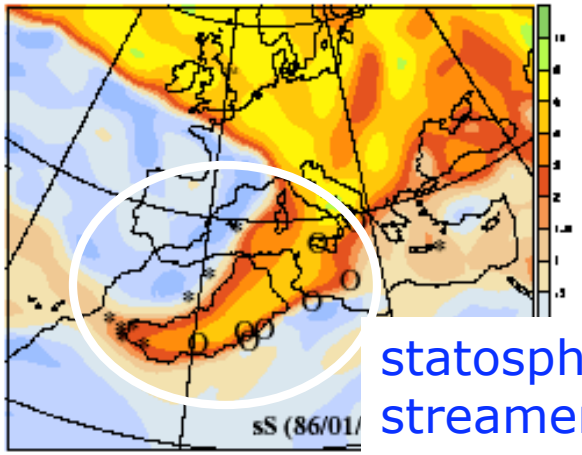
How important are PV streamers and cut-offs (Rossby wave breaking)?

How important are tropopause folds?

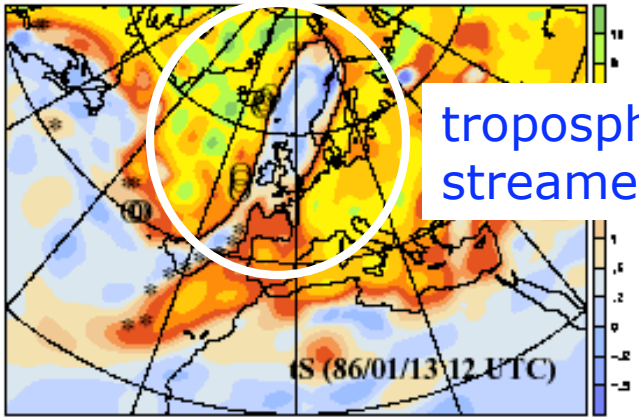
→ need for climatologies of these features

→ statistical analysis of link between individual features and STE events

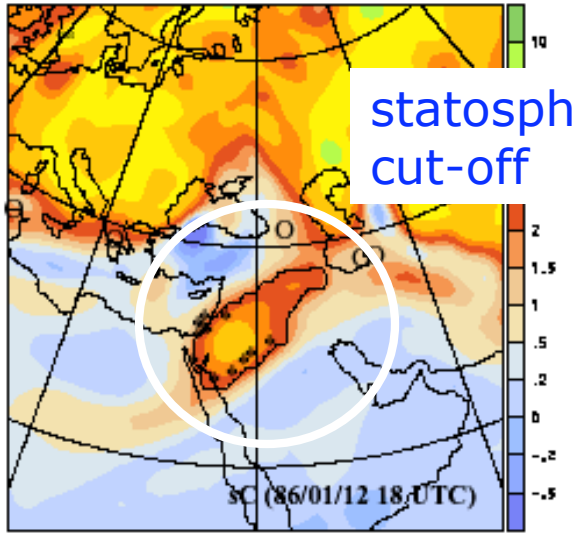
Rossby wave breaking: PV streamers/cut-offs



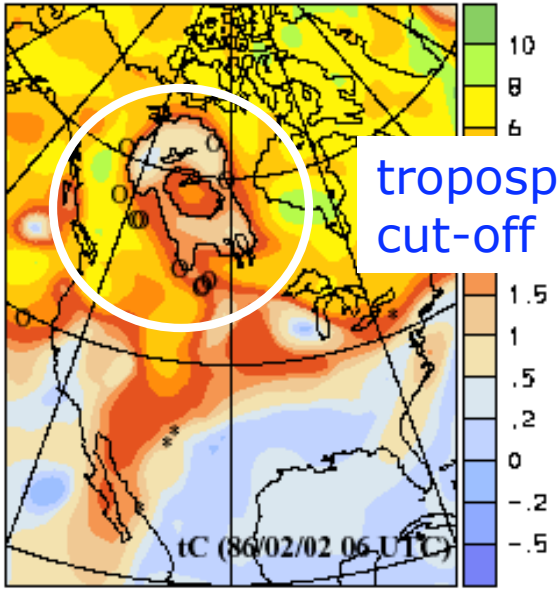
statospheric streamer



tropospheric streamer



statospheric cut-off

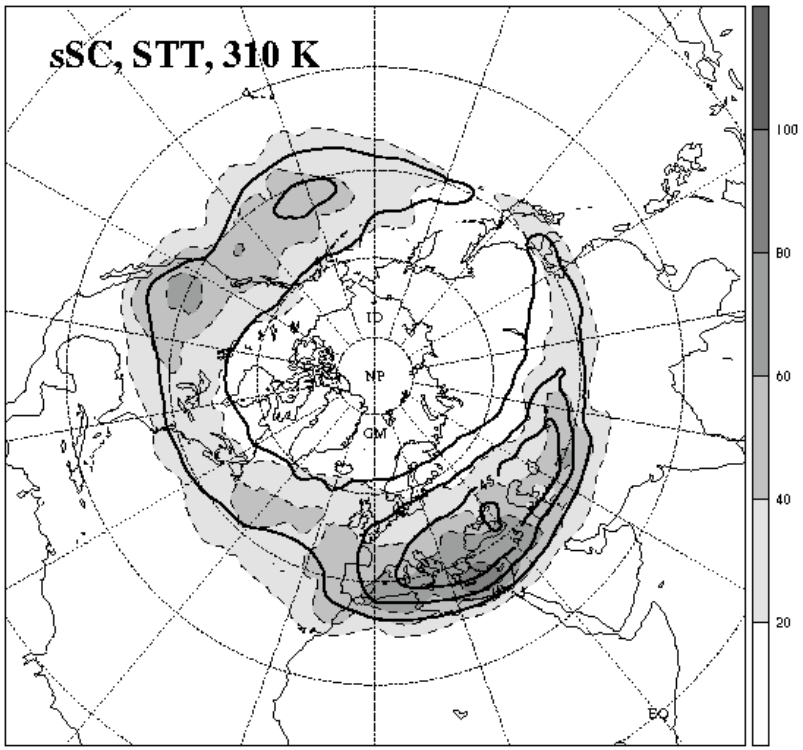


tropospheric cut-off

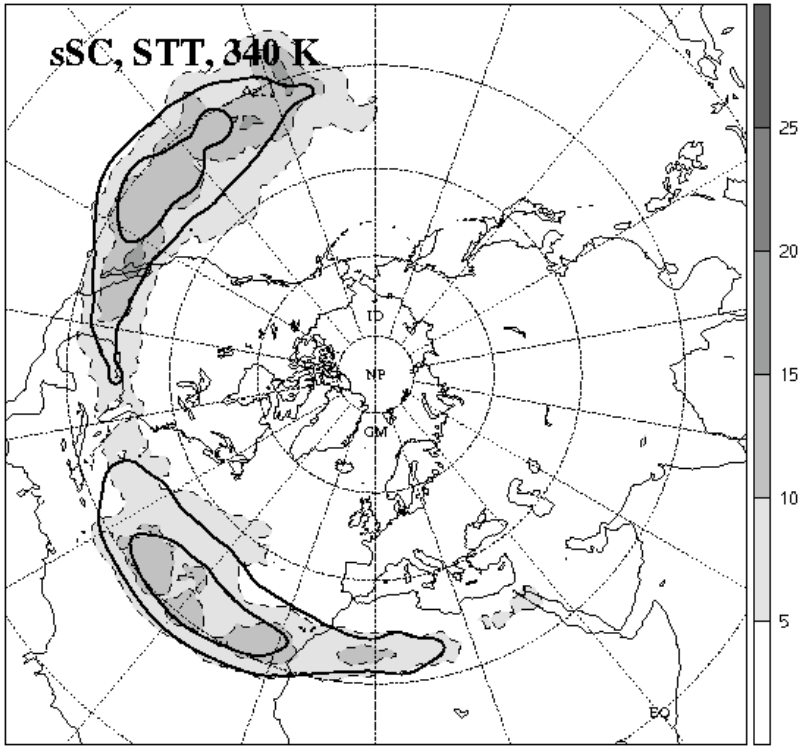
STT and PV streamers / cutoffs

Winter climatologies on ...

310K



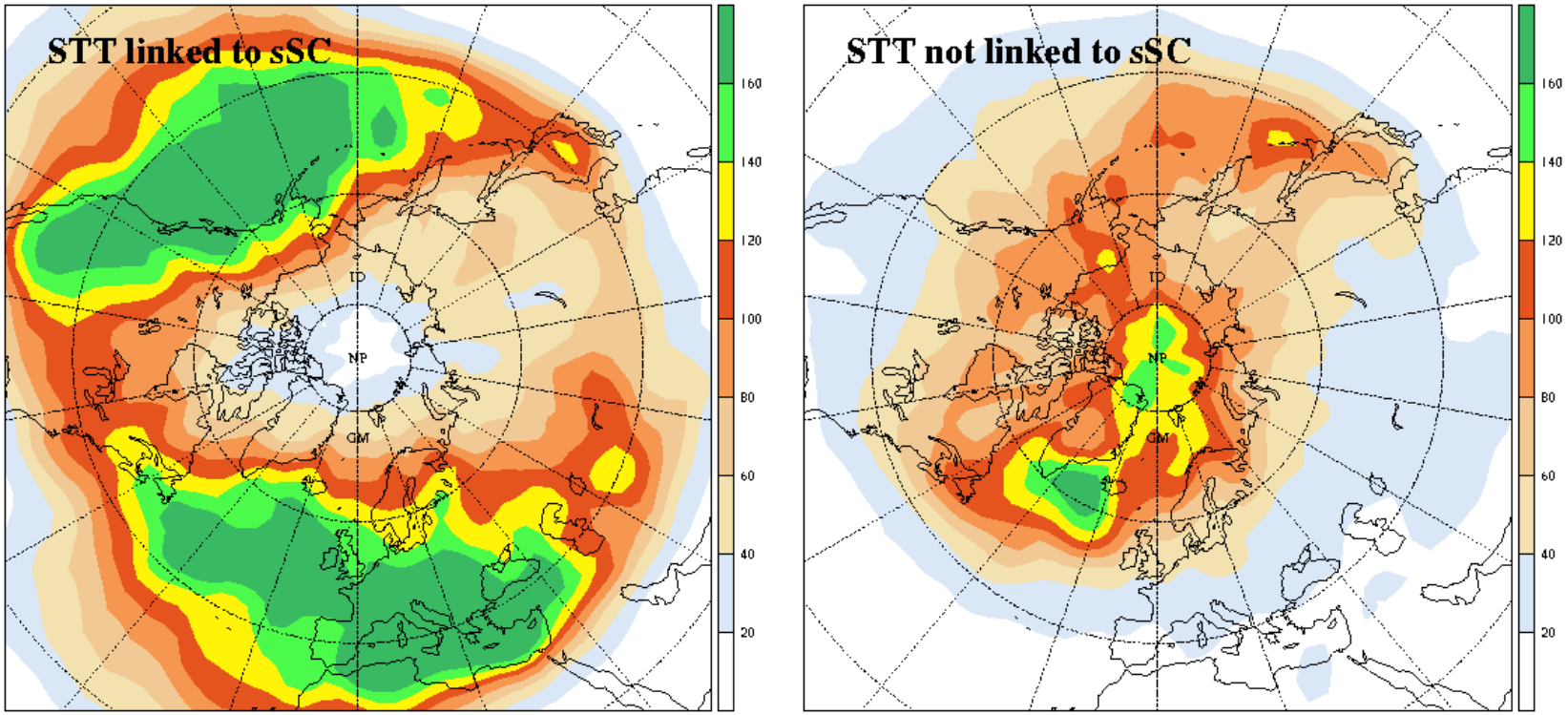
340K



Sprenger et al. 2005 (JAS, submitted)

STT and PV streamers / cut-offs

STT linked with strat. streamer/cut-off ... not linked ...



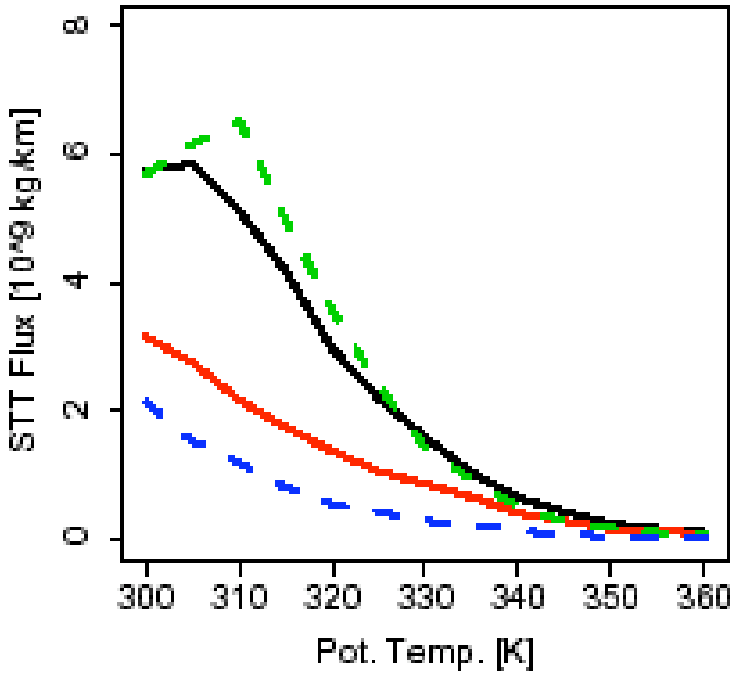
→ about 80% of STT events occur near streamer or cut-off!

Sprenger et al. 2005 (JAS, submitted)

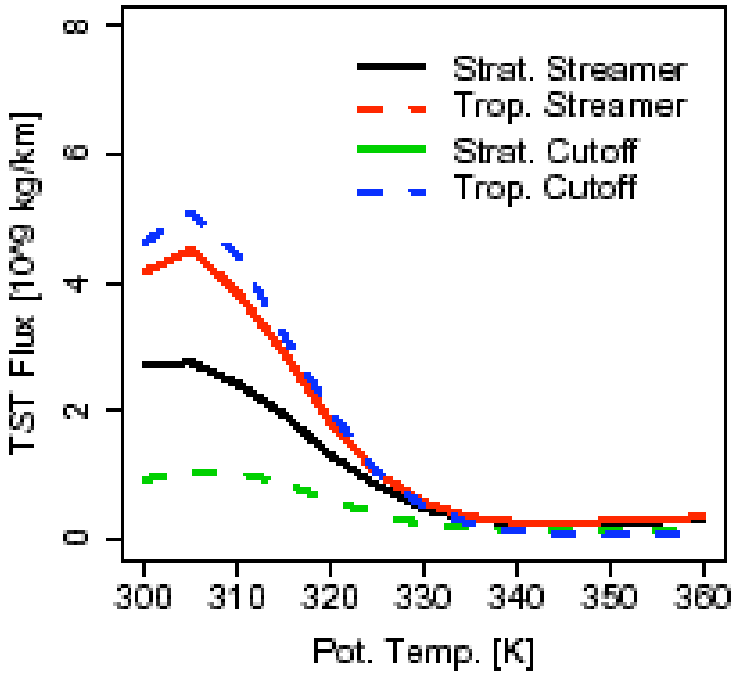
STE and PV streamers / cutoffs

STE mass flux per contour length during NH winter

STT

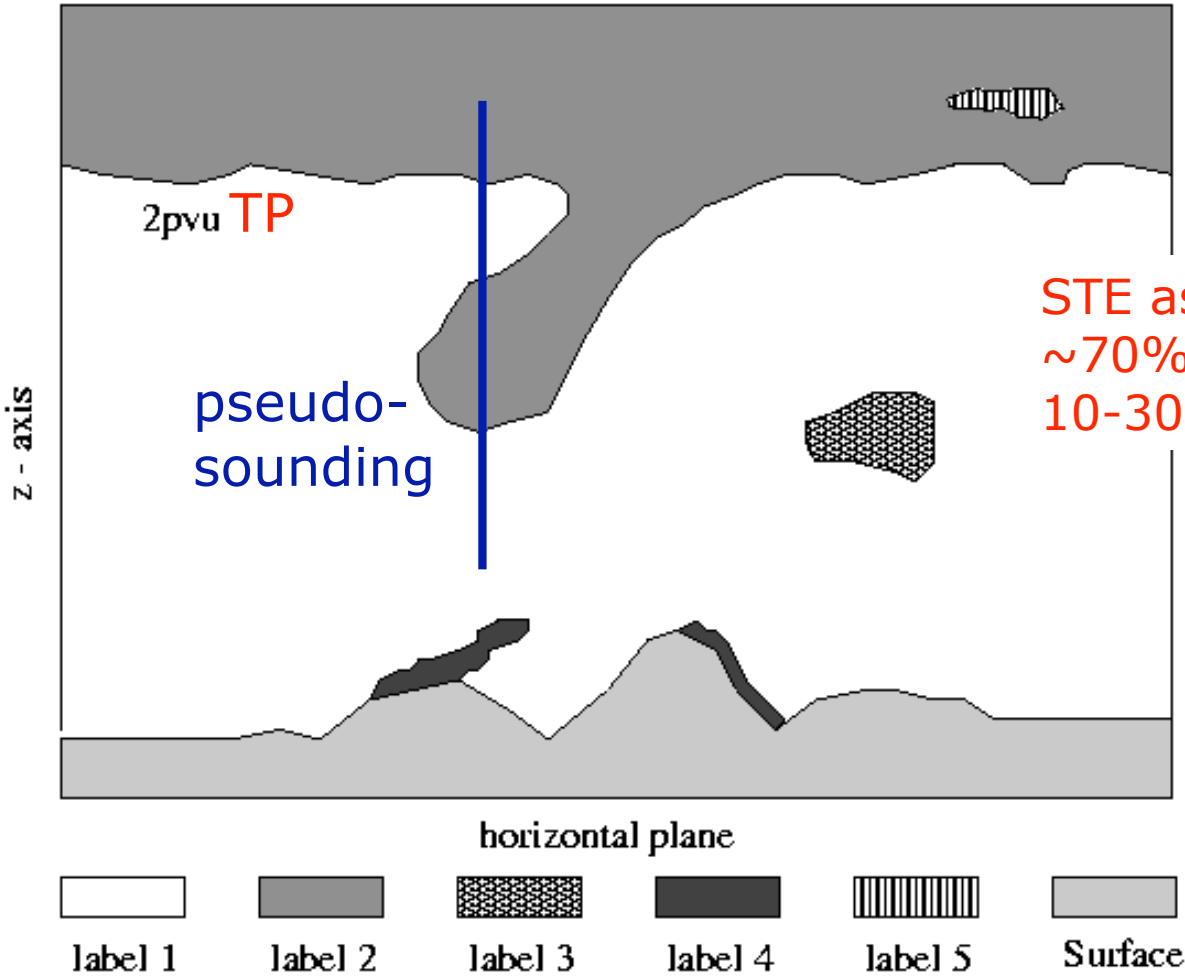


TST



Sprenger et al. 2005 (JAS, submitted)

STE and TP folds



stratosphere

STE associated with folds:
~70% in sub-tropics
10-30% in extra-tropics

troposphere

Sprenger et al. 2003 (JGR)

STE and physical processes

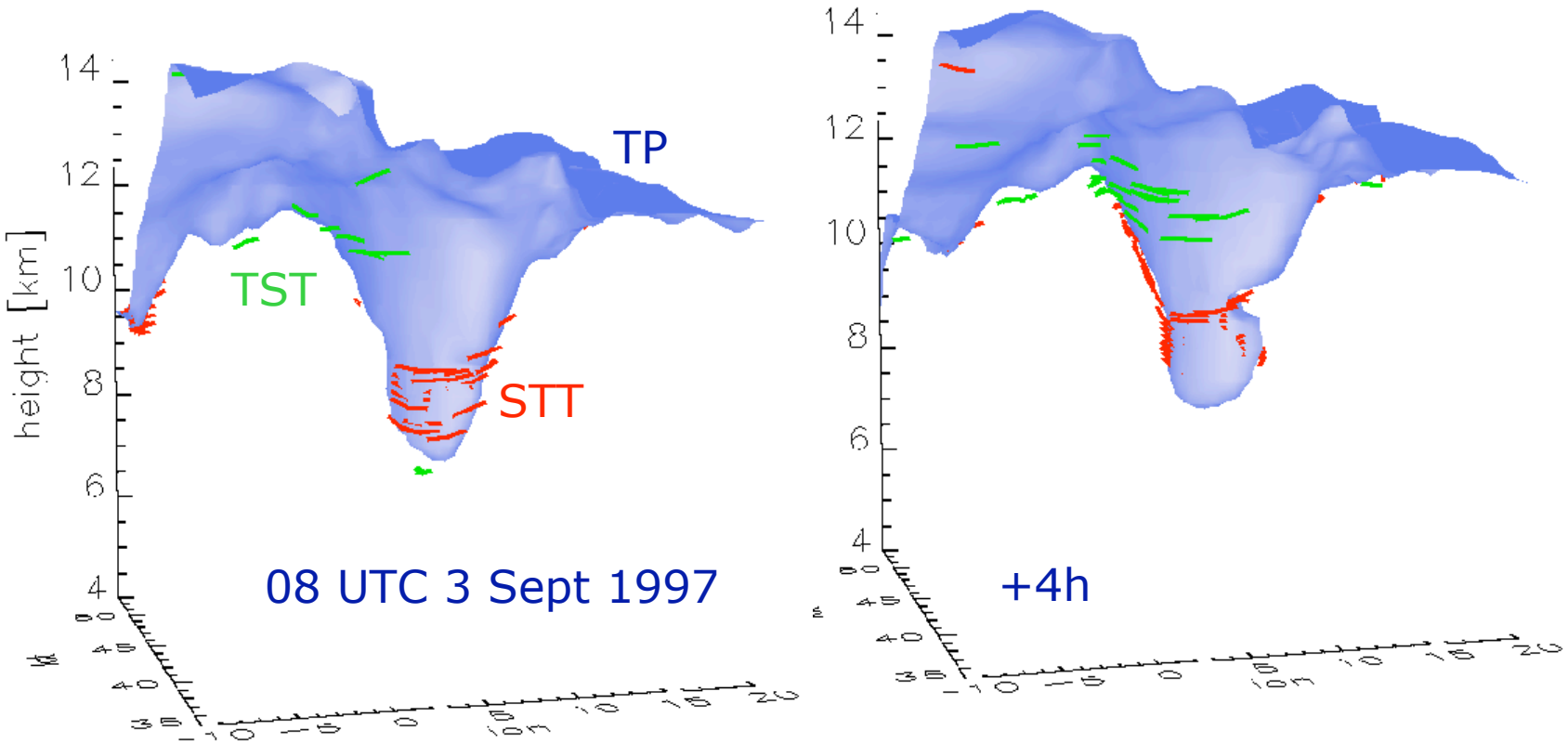
What changes PV?

- latent heat release due to condensation
- radiative processes
- turbulence

→ so far only case study results available

STT and diabatic erosion of cut-off vortex

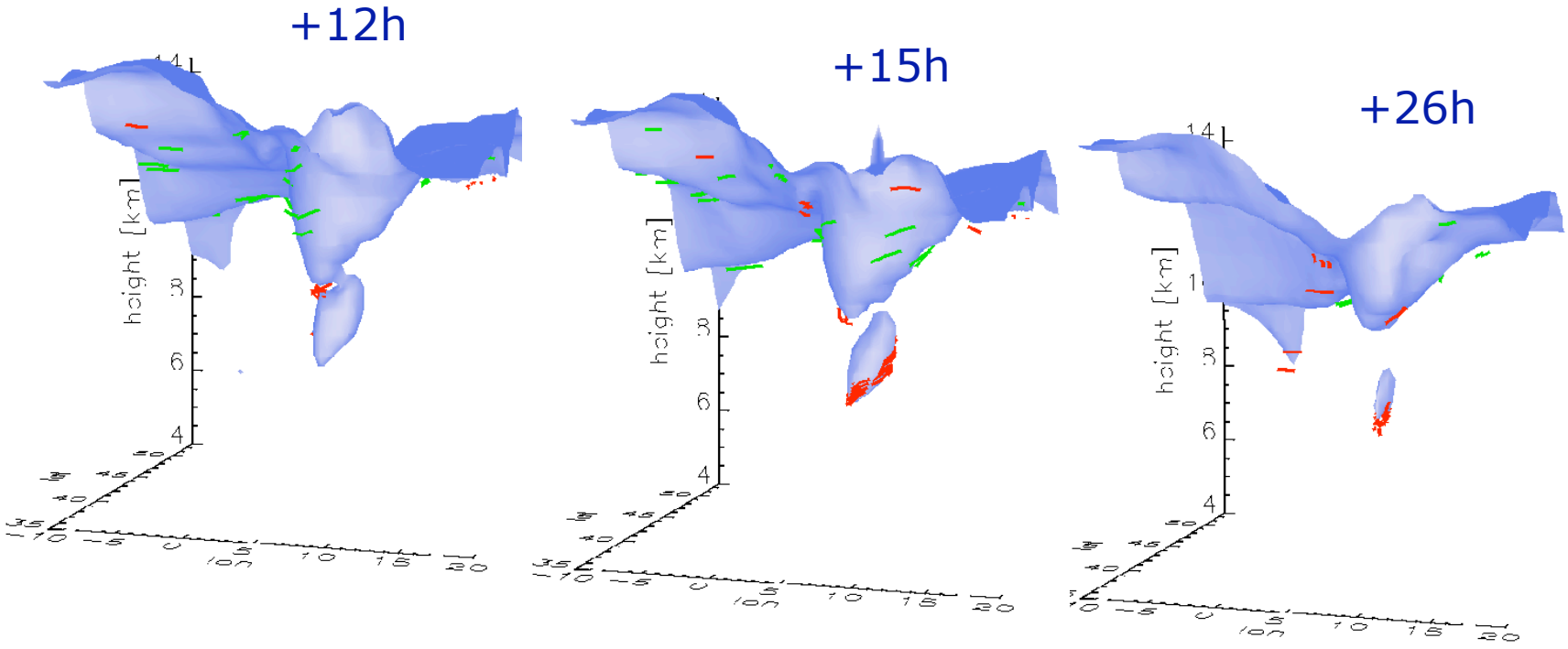
Case study over Mediterranean



Bourqui 2004 (ACPD)

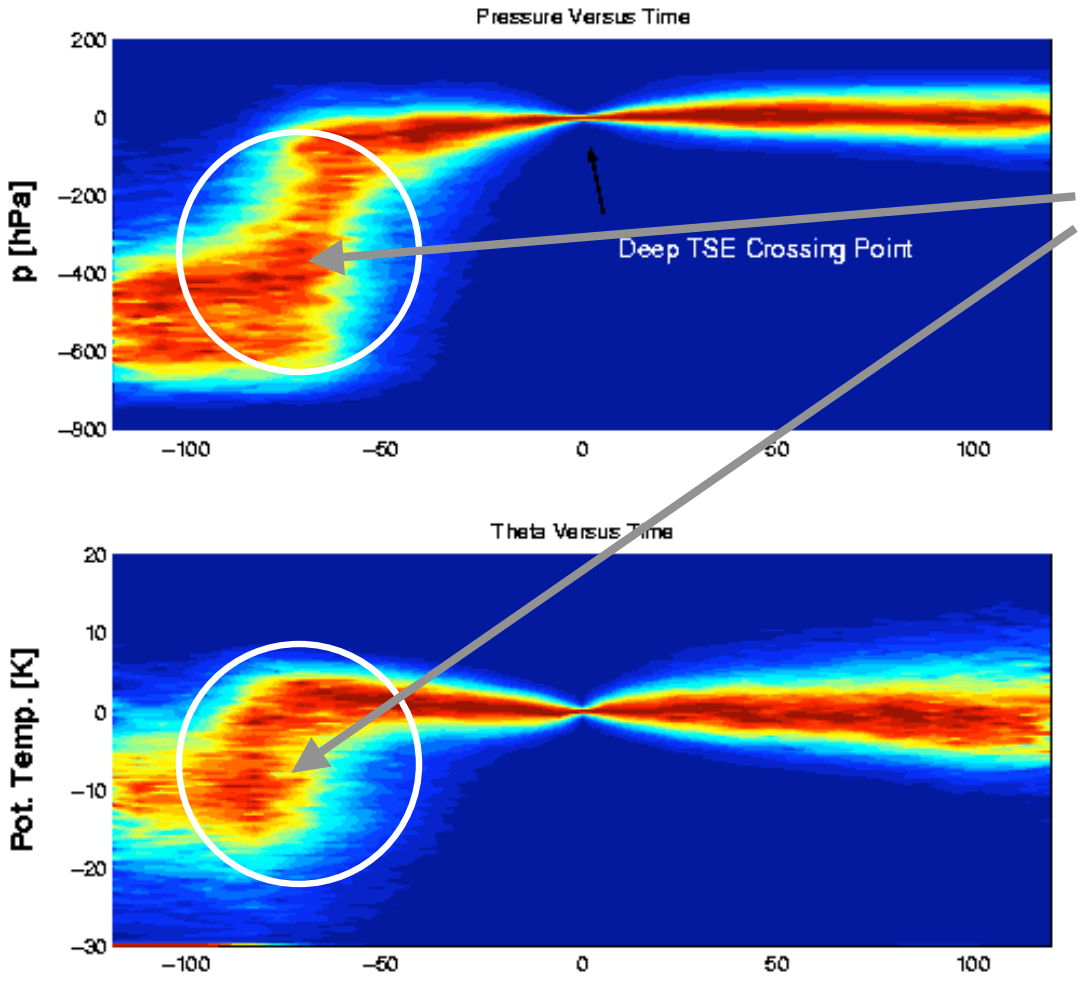
STT and diabatic erosion of cut-off vortex

Case study over Mediterranean



Bourqui 2004 (ACPD)

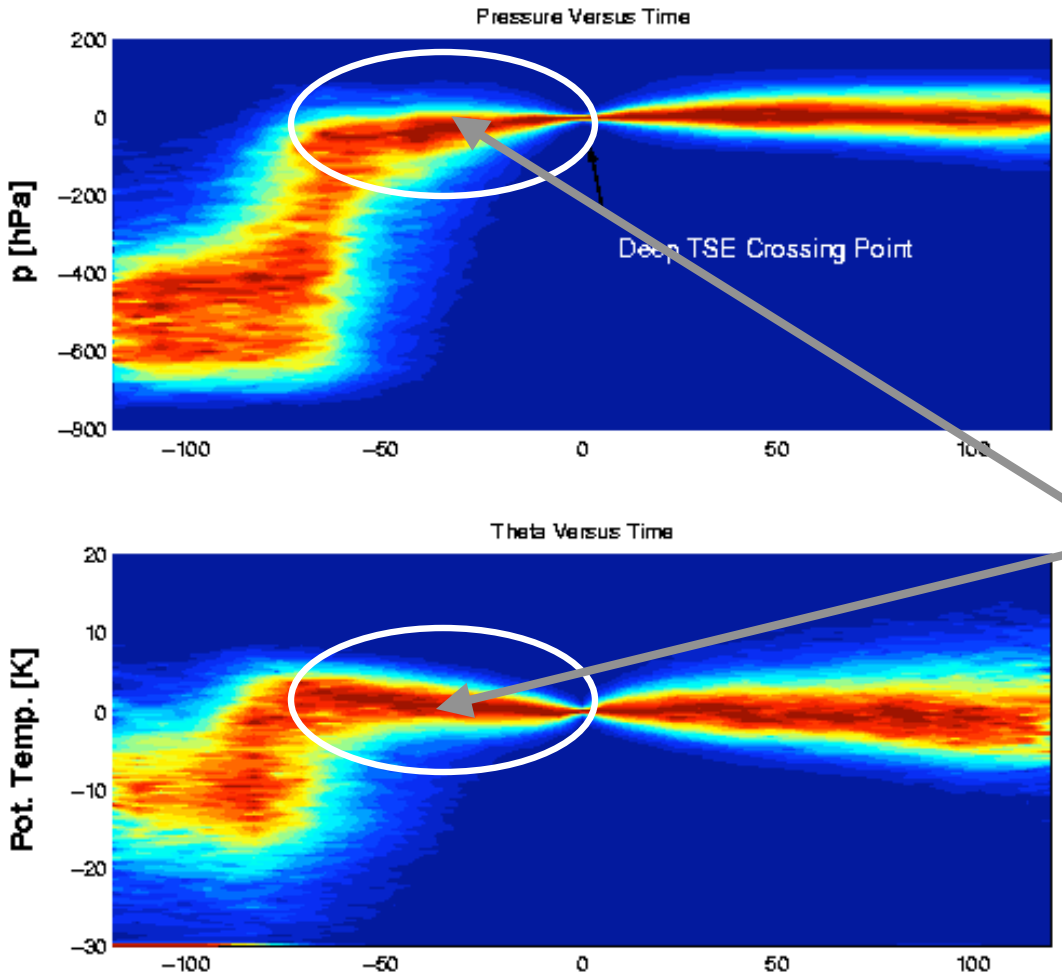
TST and radiative processes



Phase I:
moist ascent,
latent heat release,
increase of Θ

from Michael Sprenger

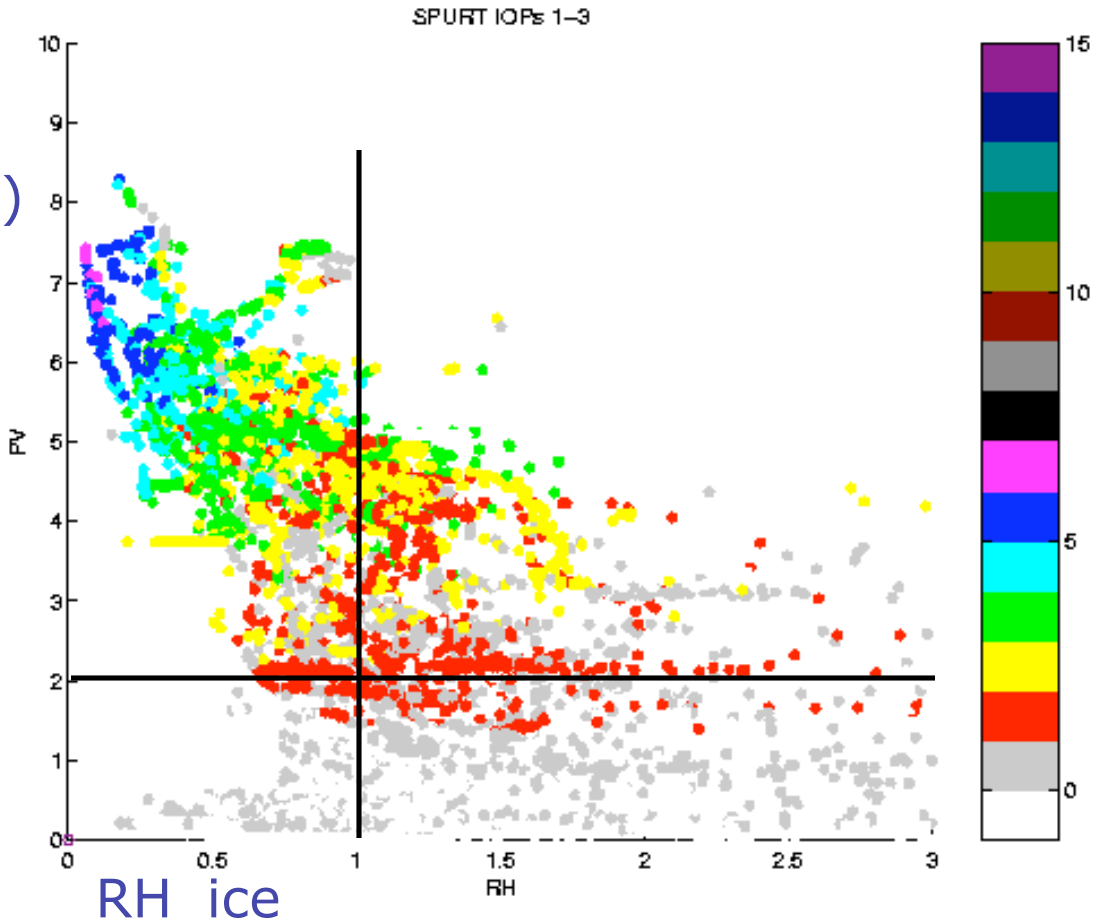
TST and radiative processes



Phase II:
(before and after TST)
decrease of Θ,
radiative cooling?

from Michael Sprenger

TST and supersaturation (SPURT campaign)



PV (obs)

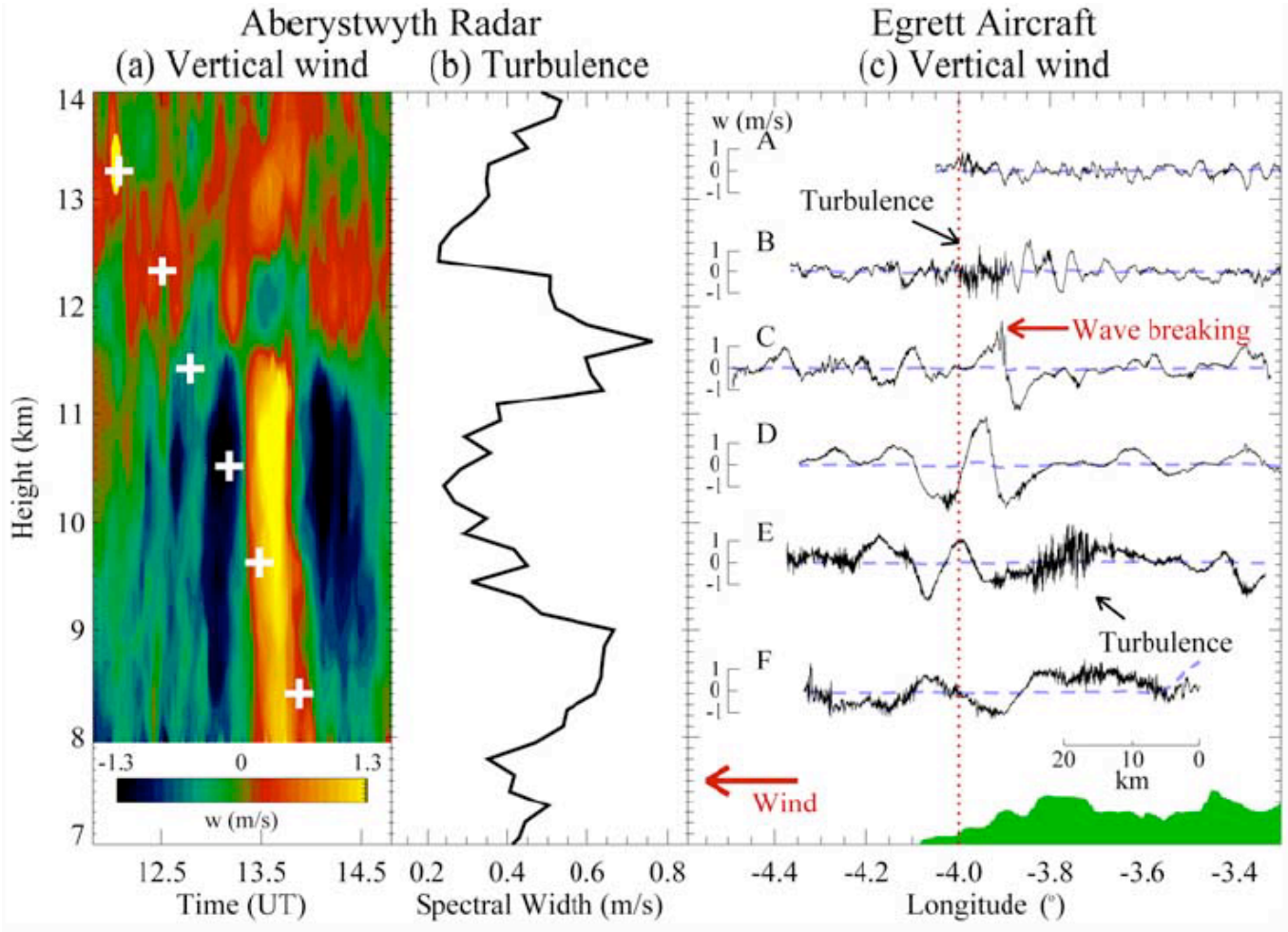
PV (min. along 10d backw. trajectories)

tropospheric origin

RH_ice (max. along 10d backw. trajectories)

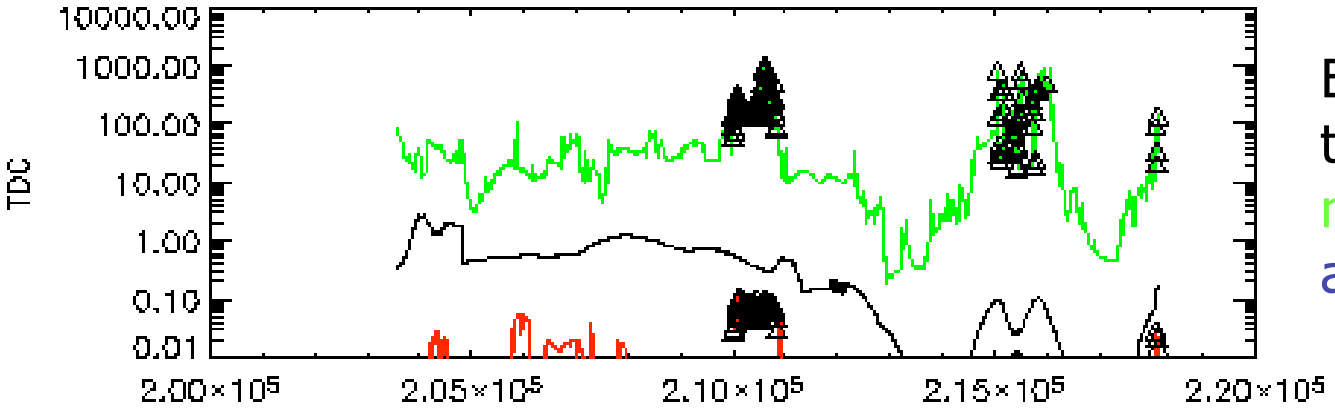
Humidity data: Cornelius Schiller

STE and gravity wave breaking

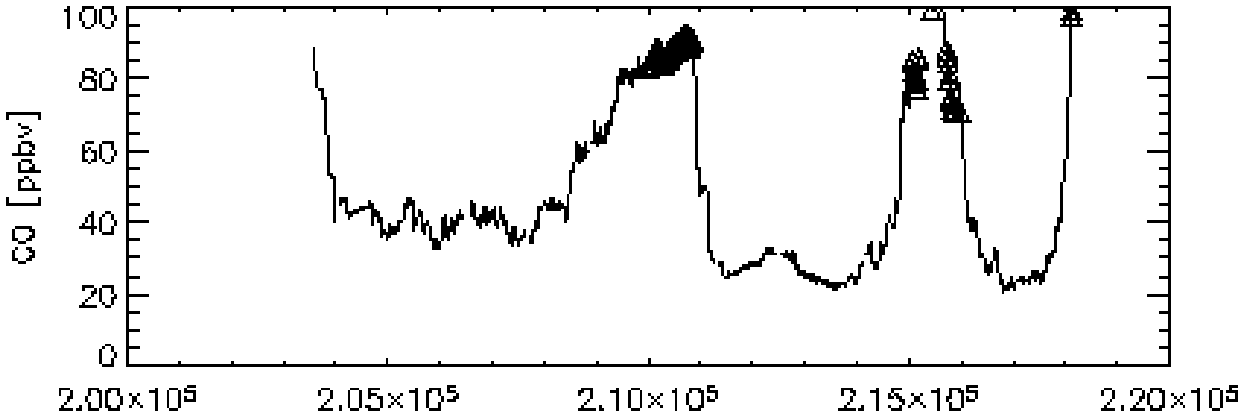


Whiteway et al. 2003 (GRL)

TST and turbulence (SPURT campaign)



ERA40
turb along flight
max / min
along trajectory



measured CO

from Peter Hoor

Concepts: transport - exchange - mixing

Distinct processes, all important, with different time scales

Climatologies

- STT: strong zonal asymmetries (TST less)
- STT: strong seasonal variations (TST less)
- exchange between PBL and LS in distinct regions
- models indicate future increase of downward ozone flux
- still to do: global fluxes of O3 and H2O; impact of monsoon systems on extratropics; analysis of past trends & interannual variability, etc.

Processes associated with STE

- PV streamers / cutoffs: very important for STE in extra-tropics
- TP folds: less important
- relative importance of latent heating, radiative processes, turbulence, deep convection, … is largely unknown